METALWORK ESSENTIALS

By

F. E. TUSTISON
Physics and General Mechanics
The Stout Institute, Menomonie, Wisconsin

and

RAY F. KRANZUSCH
Auto Mechanics and General Mechanics
The Stout Institute, Menomonie, Wisconsin

THE BRUCE PUBLISHING COMPANY
MILWAUKEE

FOREWORD

Although the writer did not participate in the preparation or editing of this book, he still had one advantage over the host of its readers. He was privileged to examine it in page-proof form. He had, in a sense, the first look and the earliest chance to evaluate. He found pleasure and satisfaction in holding these new materials up to the light of present-day needs and in checking them against certain objective factors of professional progress.

In content, arrangement, method, and adaptability, the book evidences the work-world and instructional experiences of its authors. It reflects, likewise, the progressive work done, through the years, in the institution which they represent. It exemplifies analysis, informational balance, directness, and varied approach. While fashioned to be comprehensive and elementary, it impresses with its completeness.

The book is not merely a series of manipulative processes or operations, definitely explained and illustrated. Attention has been given to the raw states, the compositions, the working properties, and the ultimate uses of the many materials suggested for classwork. There are 33 learning or teaching units, handled in more than two hundred detailed divisions. There are 263 excellent figures, largely pictures, which motivate and clarify correct and easy craftsmanship. Because many of the illustrations are multiple or composite in character, there may be said to be more than seven hundred useful views or elements. In fact, an equipment and materials list for the courses assumed, could easily be made by attention only to the pictorial offerings of these pages.

The rich combination of explanation and illustration has made it possible for any interested person to know exactly how hundreds of things may be done in the field of interest. The whole is a clear-cut presentation of whys and hows; of lay-outs and set-ups; of measurements and treatments; of tools, materials, jigs, and contraptions; of processes and projects. Questions, for study and review, accompany the several units to a total of 300 and more. Several useful tables have been included. Work with hand tools has been emphasized. Art relationships have not been neglected.

Present teachers of metalwork will be pleased to have so full a text and reference, regardless of their outlines, because any selection of units

will provide a useful core. Some who have never taught the subject will be encouraged to begin, grateful that a chart has been provided them and that a set of cautions and protections has been afforded. Fundamentally, however, the greatest service the authors have performed lies in that they have aided us in our long-time efforts to broaden the industrial offering of the schools and to enrich the experiences of students. Additional courses can be justified only by such arrays of worthy content, under good organization, and with suggestive method.

HOMER J. SMITH, PH.D.,
Professor of Industrial Education
University of Minnesota

PREFACE

Metal is used so widely and is replacing wood and other materials to such an extent that the present time is often spoken of as the Age of Metal. The strength, durability, and safety of metals are undoubtedly the chief reasons for their increased use in the manufacture of automobile bodies, ships, railroad coaches, airplanes, furniture, etc. This general increase in the use of metals makes it desirable that we become familiar with their characteristics and manipulation.

Teachers will find METALWORK ESSENTIALS adaptable for beginning courses in metalwork. While the learning units are designed to provide instructional materials for unit shops in industrial-arts and vocational courses, they are especially suited to the general shop. The units are composed of elementary experiences selected from the whole range of metalworking, and on the junior-high-school level they will provide physical and mental experiences of general educational value.

It is the aim of the book to present the hand-tool manipulations, particularly those in cutting, shaping, forming, fastening, and finishing the common metals. These processes are most generally used and have a common value because they are fundamental to all metalwork and are equally desirable for the beginner, the handy man, the homecrafter, and the mechanic. It should be understood that the book is not a treatise in sheet metal, forging, or any other specialized branch of metalwork and is not intended to prepare the student for any particular metal trade.

The metal processes included can be performed with simple hand tools and with a minimum of equipment. This makes the units adaptable to the school shop which is meagerly equipped with tools. In some of the units simple bench machines are described and instructions are given for their use. These instructions are added because the simpler machines are available in many schools and the processes involve desirable skills. In each case a hand-tool method for completing the same job is described.

The materials presented are not intended to deal with the making of specific objects, but the processes described may be applied to any project where the same results are sought. Projects are local and chang-

ing, and only the fundamental processes remain quite standard. However, for illustrating these standard processes, typical projects are used and serve the purpose of making the operations realistic.

The several metalworking processes are described in separate units and are arranged so far as possible in the order of frequency and difficulty of performance. The language is so simple that any young learner can easily understand the directions, and wherever possible, illustrations have been introduced to make the work more nearly self-instructing.

Each unit begins with a paragraph or more of necessary information to acquaint the learner with the process, when it is done, who does it, and different methods of doing it. A number of useful tables are scattered through the book, and are placed in the units where they may be used to the best advantage. Units Nos. 30, 32, and 33 are entirely informational. These units and the tables will be found of value to all workers of the common metals.

Because of the unit instruction feature, the text is adaptable to many teaching methods and is suitable for class, group, or individual instruction. It is suggested that the teacher select from the list of units those experiences which he feels are desirable for the learner to know. Projects may then be chosen which will involve the manipulations and skills selected. The book may thus serve in connection with any course of study and provide the essential processes of metalwork which remain constant.

ACKNOWLEDGMENTS

In the organization of the content of this book the authors are indebted to numerous manufacturers of metalworking tools for assistance in checking processes, criticisms, and valuable suggestions. Thanks and appreciation are especially extended to the following firms who so kindly offered their co-operation, lent us instructional pamphlets and charts, and in some cases prepared, at their own expense, cuts for use in illustrations: The Lufkin Rule Co., Saginaw, Mich.; Peck, Stow & Wilcox Co., Southington, Conn.; Cleveland Twist Drill Co., Cleveland, Ohio; Parker Kalon Corp., New York, N. Y.; Wm. Dixon, Inc., Newark, N. J.; Henry Disston & Sons, Chicago, Ill.; Hisey-Wolf Machine Co., Cincinnati, Ohio; S. W. Card Manufacturing Co., Mansfield, Mass.; Toledo Pipe Threading Machine Co., Toledo, Ohio; Desmand-Stephen Mfg. Co., Urbana, Ohio; American Steel & Wire Company, Chicago, Ill.; and Alumaweld Co., Chicago, Ill.

The authors are also indebted to several of their colleagues for valuable assistance. Mr. R. L. Welch acted as consultant for several sheet-metal procedures and gave timely suggestions. Mr. H. C. Milnes aided in

making the unit on Molding a part of the text, and Mr. Arthur G. Brown co-operated in developing the general organization of the units.

We are especially grateful to Dean C. A. Bowman, of the School of Industrial Education, The Stout Institute, for his interest in analysis and its effect upon the development of instructional content in the field of Industrial Arts.

The Authors

CONTENTS

METALWORK ESSENTIALS

Unit 1

TO MEASURE

The metalworker must learn to measure. First, he must know how to lay off (measure) a given distance; second, he must know how to measure the various dimensions of an object that must be known in order to be able to make another object like it.

Accurate measuring is required in many trades. A measurement indicates the number of units between two points. The common standard units of linear measurement for the metalworker are the inch and the foot. For instance, a measurement of 2½ in. indicates that there are 2 and ½ units (of an inch) in the dimensions stated.

The thickness of metal is often indicated in gauge numbers as well as in inches. The decimal inch dimensions corresponding to the gauge numbers are usually indicated to the thousandths or ten-thousandths part of an inch. In Figure 6 are listed some of these gauge numbers for thickness of sheet metal, and the corresponding dimension in inches is given for convenience of comparison.

In order to develop skill in making accurate measurements, the metalworker must exercise extreme care from the very beginning. A skilled mechanic often works to a hundredth or even a thousandth of an inch for good results.

Steel rules, which are used in this work, should be handled carefully so that the edges do not become nicked or the rule bent. A well-kept rule will give correct measurements and an accurate layout.

Tools: Steel rule or circumference rule; scriber or scratch awl; caliper rule; metal gauge; dividers.

Material: Sheet metal, bar, and rod to be measured.

METHODS:

1. Rules Commonly Used in Metalwork

One piece steel rules are most commonly used by the metalworker. They vary in length from 1 in. to 6 ft. The shorter lengths are often called "steel scales" and have graduations (divisions) as small as 1/100

in. (see Fig. 1). Most steel rules are numbered on both sides and are divided into a variety of graduations.

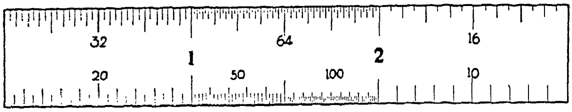

Fig. 1. A 3-in. steel rule or scale

Another common rule for the metal shop is the 36-in. circumference rule. It has special graduations for determining the dimensions of circles, and also special tables for the sheet-metal worker. For example, in Figure 2 the top graduations show the diameter of circles, and the bottom graduations that line up with them give the corresponding circumferences. Thus the circumference of a 2-in. circle is about 6¼ in. Useful tables of dimensions for metal containers are found on the other side of the circumference rule.

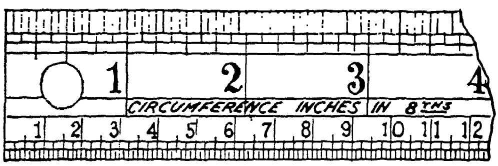

Fig. 2. Circumference rule

2. Graduations on the Rules

One cannot measure with a rule or any measuring device without knowing the value of its divisions. Examine the different rules available in the shop and note the graduations or divisions. On rules 12 in. and over, the common graduations are inches, half inches, quarter inches, eighth inches, and sixteenth inches. Some rules have divisions of thirty-seconds and sixty-fourths, and still others are divided decimally, reading as low as 1/100 in. Very finely graduated steel rules are used by the skilled workman for accurate measurement.

3. Lay Off a Distance

Accurate distances are always laid off with the rule on edge (see Fig. 3). This allows a mark to be placed exactly in line with the graduation desired. The scriber or scratch awl is always used for accurate marking. See that the scriber point is slender and sharp to do good work.

For rough measurement, a rule may be placed flat on the surface to

be measured, and marks made with soapstone or chalk. However, for all final dimensions, always use the scriber or awl for marking.

4. Measure a Straight Dimension

To measure a certain distance or dimension, place the rule so that one end is exactly in line with one of the surfaces or marks on an object,

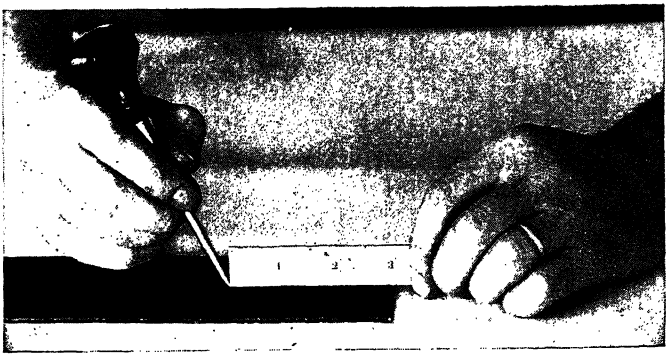

Fig. 3. Use a rule on edge for accuracy

and read the graduation on the scale that is in line with the other mark. Hold the rule on edge if accuracy is necessary. Rules with a special hook on one end are convenient for measuring outside dimensions. The hook serves as an end guide and helps to line up the end of the rule.

5. Measure with a Caliper Rule

The most accurate measurements of the outside diameters of rods are made with a caliper rule (see Fig. 4). Such measurements are often

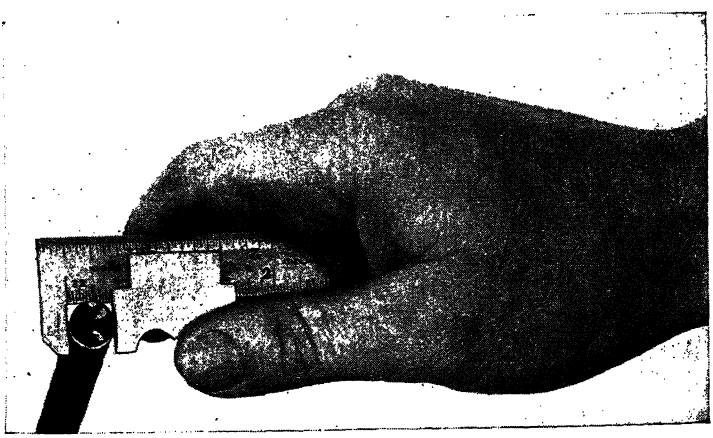

Fig. 4. Diameters are quickly measured with a caliper rule

necessary in metalwork, and are taken by clamping the jaws of the rule tightly to the rod, then reading the dimension on the scale between the jaws. The caliper rule will also measure the thickness of sheet metal, but more accurate dimensions may be obtained here with the metal gauge.

6. Measure the Thickness of Sheet Metal

The metalworker very often finds it necessary to measure the thickness of sheet metal. The experienced workman usually does this by

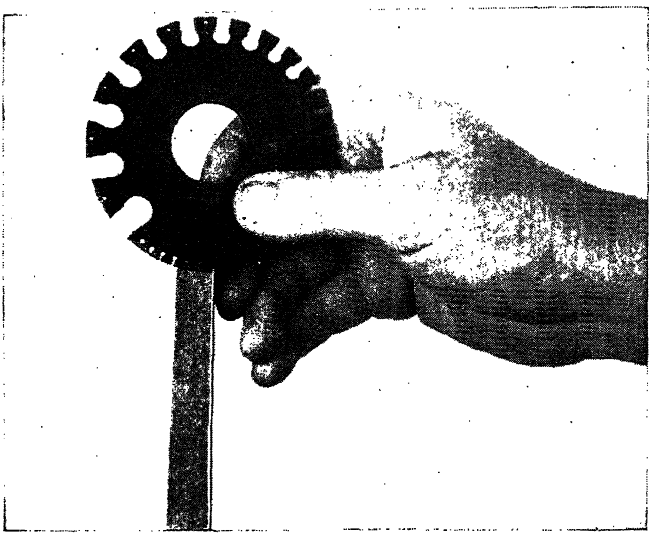

Fig. 5. Measuring sheet metal with a metal gauge

inspection, but the beginner must learn to use the metal gauge. A common metal gauge is shown in use in Figure 5. To measure a thickness, slip the gauge over the edge of the metal, using the smallest slot that will just fit over that piece of metal, and read the gauge number or decimal equivalent at that slot. When you think that the proper slot has been selected, you may find it necessary to push quite hard on the gauge to slip it over the metal as the edge of the metal sometimes is burred. For correct measurement select an edge of the metal free from burrs or kinks. Metal up to 3/16 in. in thickness usually is measured and ordered by the gauge number. Many articles and projects are made from materials whose thickness is indicated by a gauge number. The thickness of 1/8 in. is about No. (gauge) 11. The gauges used for the measurement of sheet and plate iron and steel is called "U. S. Standard" (see Fig. 6).

Number of Gauge	*Approximate thickness in fractions of an inch*	*Approximate thickness in decimal part of an inch*	*Weight per square foot in pounds avoirdupois*
0000000	1–2	.5000	20.00
000000	15–32	.4688	18.75
00000	7–16	.4375	17.50
0000	13–32	.4063	16.25
000	3–8	.3750	15.00
00	11–32	.3438	13.75
0	5–16	.3125	12.50
1	9–32	.2813	11.25
2	17–64	.2656	10.625
3	1–4	.2500	10.00
4	15–64	.2344	9.375
5	7–32	.2188	8.75
6	13–64	.2031	8.125
7	3–16	.1875	7.5
8	11–64	.1719	6.875
9	5–32	.1563	6.25
10	9–64	.1406	5.625
11	1–8	.1250	5.00
12	7–64	.1094	4.375
13	3–32	.0938	3.75
14	5–64	.0781	3.125
15	9–128	.0703	2.8125
16	1–16	.0625	2.5
17	9–160	.0563	2.25
18	1–20	.0500	2.
19	7–160	.0438	1.75
20	3–80	.0375	1.50
21	11–320	.0344	1.375
22	1–32	.0313	1.25
23	9–320	.0281	1.125
24	1–40	.0250	1.
25	7–320	.0219	.875
26	3–160	.0188	.75
27	11–640	.0172	.6875
28	1–64	.0156	.625
29	9–640	.0141	.5625
30	1–80	.0125	.5

Fig. 6. United States Standard Gauge for Sheet and Plate Iron and Steel

7. Measure Irregular Lengths

It is quite easy to measure a straight dimension, but when the part of a project is curved or very irregular, the length is not so easily obtained.

When full-sized drawings of curved parts are available, the length of the piece can be obtained as follows: Draw a center or measuring line through the entire part. The length of the part is the actual length of

this center line. A wire or strip made to conform to this line and then straightened will give the desired length (see Fig. 7).

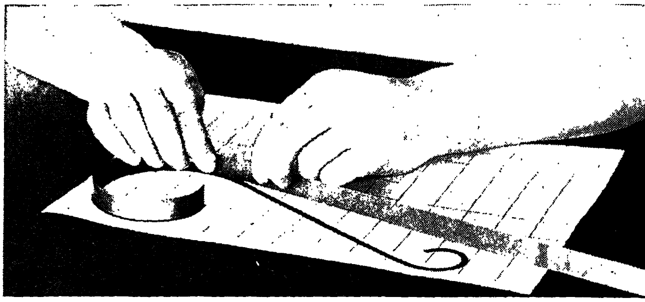

Fig. 7. Measuring the length of a curved part with a metal strip

STUDY QUESTIONS:

1. Name several reasons for taking measurements.
2. Name two of the standard English units of linear measurement.
3. What is the circumference of a 3-in. circle? Read from Figure 2.
4. Name some cautions for handling metal rules.
5. Name the common divisions of the inch on the ordinary rule.
6. Name some very fine divisions on "steel scales."
7. How is the rule placed for accurate measurement?
8. What marking tool is used on metal for accuracy?
9. What is the use of the caliper rule?
10. How is the thickness of sheet metal usually measured?
11. State how to determine the accurate length of a curved part of a project.

Unit 2

TO LAY OUT

In order that the metalworker may work to dimensions, it is necessary that the metal be laid out. This means that straight lines, curved lines, circles, and centers are marked on the surfaces of the metal to guide the worker. To make an accurate project the layout must be properly located and drawn.

The common laying out tools are the ordinary square, the combination square, the dividers, the center punch, and the scratch awl or scriber. The squares are used as guides for the laying out of straight lines, and the scratch awl is the chief marking tool.

Since lines scribed on many metals are difficult to see, such surfaces are coated to make the markings more visible. On finished surfaces where *exact* layout is necessary, a copper sulfate solution is sometimes used. This is prepared by mixing an ounce of copper sulfate salt, four ounces of water, and several drops of nitric acid. This solution, when brushed on an iron or steel surface, gives it a copper color. Lines scribed on such a surface show up plainly and do not rub off easily.

For less permanent coatings, the surface may be rubbed with white or blue chalk or may be painted with a whitewash solution. A good white solution is made of pure whiting mixed with gasoline or alcohol to the consistency of thin paint, and is put on with a brush. Such a solution dries quickly, leaving a white surface for the laying out of lines.

Tools: Common square; combination square; center punch; dividers; scriber or scratch awl.

Materials: Metal to be laid out; pattern or template; marking solution (if necessary).

METHODS:

1. Lay Out with a Common Square

The metal square is used to lay out lines at an angle of 90 deg. A common size (12 by 8 in.) for the metal shop is shown in use in Figure 10, where the operation involves the squaring of a piece of sheet metal. For accurate layout a scriber or awl is used for marking, and the square

must be held tightly in place as the mark is made. A larger square may be used on a larger piece of metal.

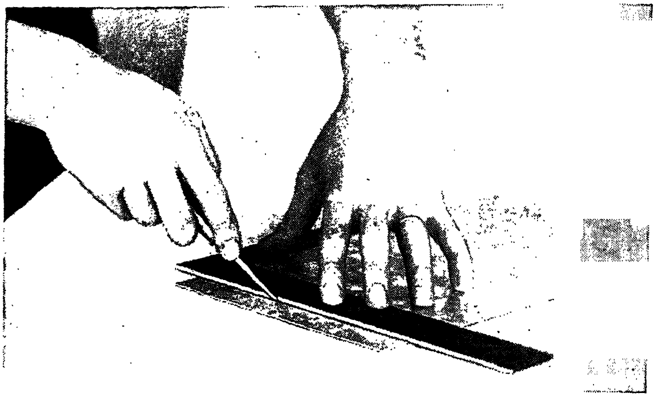

Fig. 10. Laying out with a steel square

2. Lay Out with a Combination Square

A combination square is a special metalworker's tool. It consists of a special rule with a sliding head. A clamping screw will hold the head at any desired place. Angles at 90 and 45 deg. can be made with the head

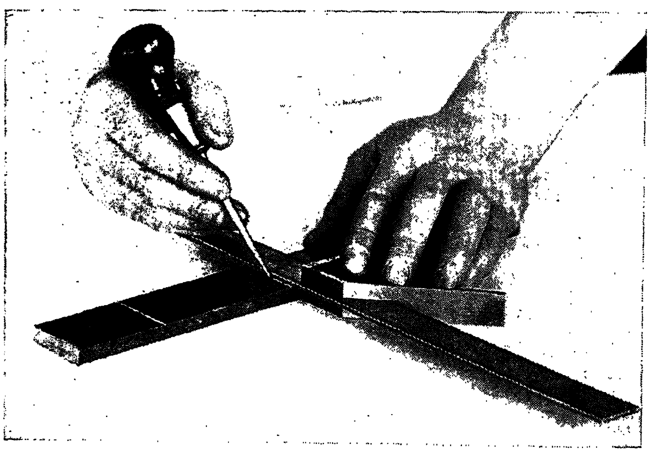

Fig. 11. A combination square in use

shown in Figure 11. Here the combination square is used to square a line at 90 deg. across a metal bar. The opposite side of the head gives an angle of 45 deg.

To lay out lines at angles other than 90 and 45 deg., a protractor head

is used on the rule (see Fig. 12). The head is adjustable to different angles, and the rule is used as shown in Figure 12.

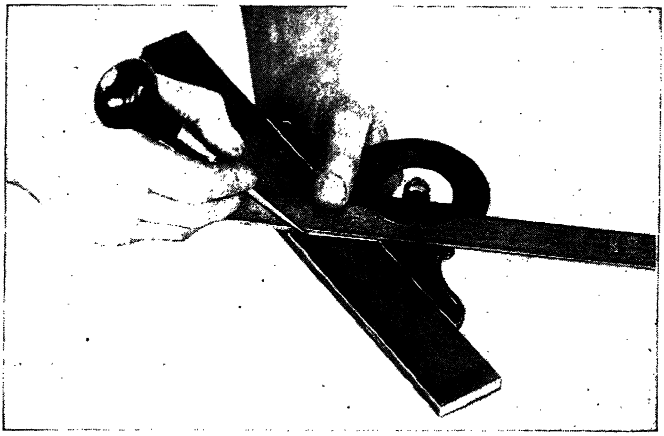

Fig. 12. Rule with protractor head

3. Locate the Center of a Round Bar

A center square clamped on the rule is used to locate the center of a round bar. To locate the center, use the tool as shown in Figure 13, and mark along the rule. Then turn the tool at *right angles,* and make another mark. The intersection of these lines is the center of the bar.

Fig. 13. Locating center of a round bar

4. Lay Out with a Pattern (see Fig. 14)

Patterns or templates of metal are often furnished for the beginning projects. At other times pupils make their own patterns, which are desir-

able when a number of duplicate parts are to be made and when irregular shapes are constructed. To mark the parts or shapes, place the pattern at the desired place on the metal, and hold it firmly to the metal as you

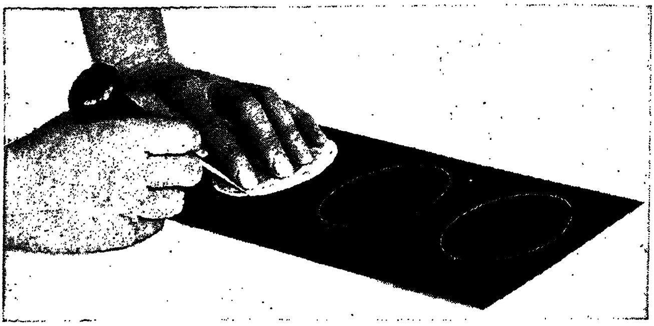

Fig. 14. Laying out curves with a pattern

scribe the outline. Hold the scriber at an angle so the point will make the outline at the exact edge of the pattern. Patterns made of paper are difficult to outline with a scriber, and should be used only when and where a pencil can be used for marking.

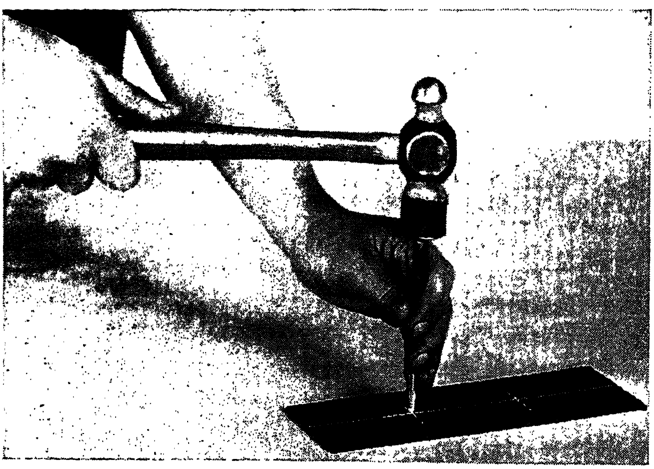

Fig. 15. Center punching for holes

5. Center Punch

Center-punch marks are sharp-pointed depressions made with a punch and a hammer. A center punch always is used to mark the metal where drilling is to be done, and sometimes it is used to mark iron at points

where it is to be bent or twisted. Center-punch marks also are useful for marking centers when it is desired to draw circles with dividers.

In locating centers for holes, lay out two lines as indicated in Figure 15. Then center punch the intersection as shown. Make a very light punch mark at first, and then inspect to see if it is properly located. If a slight error is noticed, slant the punch and drive it in the direction necessary to center the mark.

6. Lay Out a Circle

The dividers are used to lay out a circle. Figure 16 shows a wing type of dividers in use. Set the points of the dividers to accurate dimensions

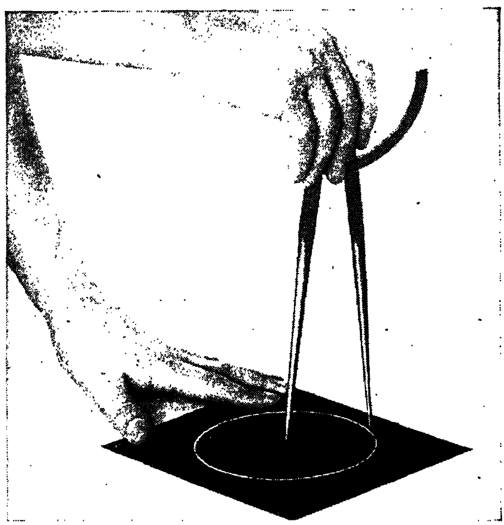

Fig. 16. Laying out circle with dividers

by checking directly on a rule. Place one point at the center of the desired circle and swing the other point to the right or left. Lean the dividers slightly in the direction of rotation. The divider points should be sharp to do good work on metal.

7. Lay Out Equal Spaces on a Ring

It is sometimes necessary to divide a metal ring into equal parts. Any number of equal spaces can be laid out on a ring or circular disk by first drawing a circle equal in diameter to the outside diameter of the ring or disk on a piece of pattern paper, and then dividing the circle with dividers, by the trial method, into the number of spaces required. The ring or disk then is placed on the circle which has been divided into

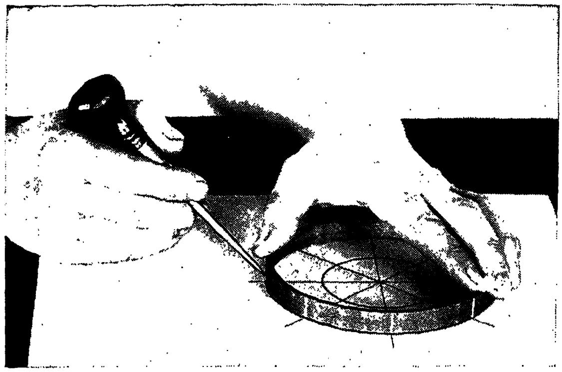

Fig. 17. Laying out equal spaces on a ring

the required number of parts, and the divisions are transferred to the ring or disk with a scriber or scratch awl as shown in Figure 17.

STUDY QUESTIONS:

1. How are surfaces sometimes coated for laying out?
2. What is the use of the combination square with the regular head?
3. What is the use of the protractor head on a steel rule?
4. How is the center of a round bar accurately located?
5. When are patterns desirable?
6. What is the objection to paper patterns?
7. What are the uses of center-punch marks?
8. How are circles laid out on metal?
9. How may a ring be divided into equal parts?

Unit 3

TO CUT WITH TINNER'S HAND SNIPS

The tinner's snips is a hand shears made in a number of styles, each with different shaped blades, used by the metalworker for cutting sheet metal of 20 gauge and lighter.

Some of the common styles of snips are: straight, curved, hawk's bill, and double-cutting (see Fig. 20). These styles are suited for different

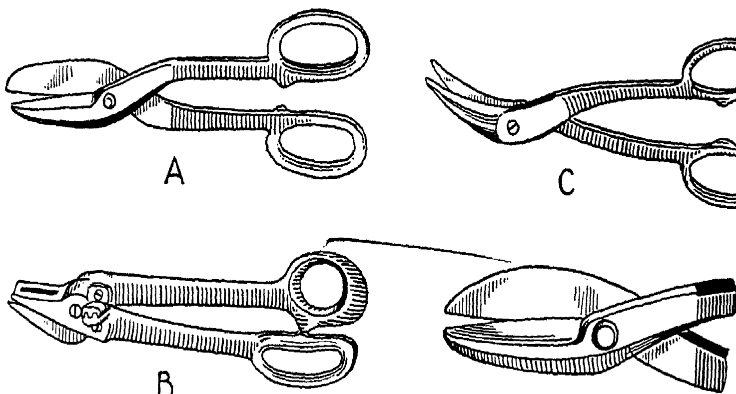

Fig. 20. Common types of tinner's snips. A, straight snips; B, double-cutting; C, hawk's bill; D, curved snips

types of cutting. The straight-bladed snips are the most commonly used. They are furnished with cutting-blade lengths of from 2 to 4 in., and have an over-all length from 7 to 16 in. The lengths in common use are 11½ to 13¾ in. in over-all dimensions.

Tinner's snips are designed to cut only flat, thin metal, and must not be used to cut wire, nails, or any hardened metal. Such cutting will dull or nick the snips.

Snips should be kept sharp, and must be tight enough at the joint to allow them to work freely. Oiling at intervals will aid in operation and upkeep.

Tools: Snips; measuring and marking tools.

Material: Thin, flat metal to be cut.

METHODS:

1. Lay Out for the Cut

See Unit 2 for laying out on metal.

2. Select the Snips

The straight snips are used for all straight cutting, but also may be used to cut *outside curves*.

This type of snips is used more often than any other, and serves for

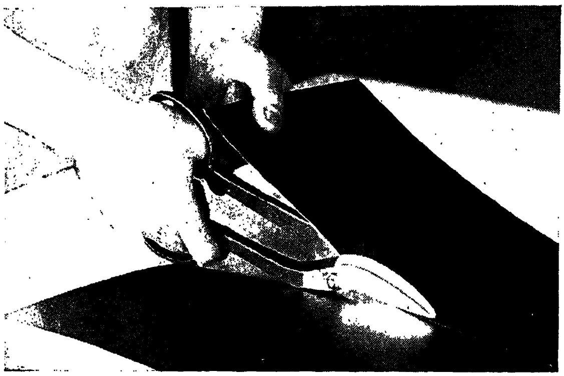

Fig. 21. Using straight snips for cutting straight metal

general cutting. Figures 21 and 22 show these snips in use for straight cutting. The straight snips also can be used to trim the end of a pipe or a cylinder. They are used in a similar manner as shown in Figure 22.

The curved snips are best suited for removing metal from the *inside of a curve* (see Fig. 23).

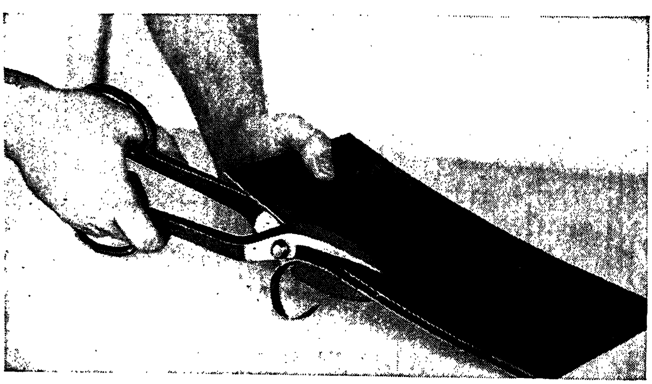

Fig. 22. Trimming the edge of a piece of metal. The end of a cylinder would be trimmed in like manner

The hawk's bill is a combination scroll and circular cutting snips. It will cut circles and curved designs of very small dimensions, and may be used on the inside as well as on the outside of a curve (see Fig. 24).

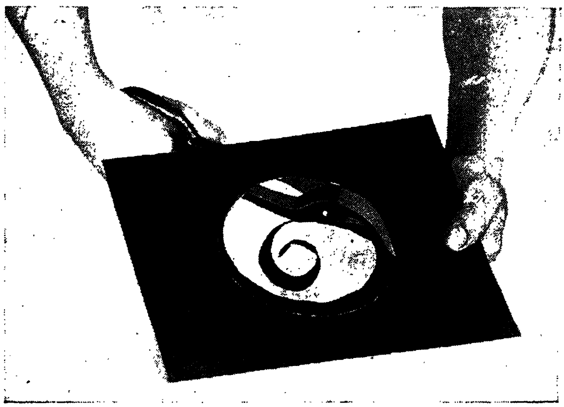

Fig. 23. Cutting an inside curve with a curved snips

The double-cutting snips shown at B in Figure 20 are useful for cutting pipes or ducts into lengths.

3. Cut with the Straight Snips

For making long cuts, open the snips, and insert the metal between the blades or, as it is called, into the throat as far as possible, with the

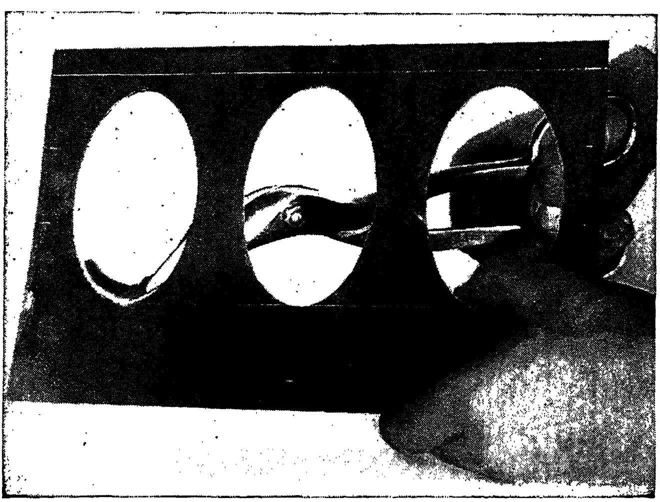

Fig. 24. Cutting curved openings in the sides of a porch lantern with a hawk's-bill snips

or the torch is not available, use the coals of a wood fire. The tinner often uses a charcoal furnace which he carries with him. Place the whole body of the copper directly in the flame or right among the red-hot coals, and let the copper become hot enough to melt solder, but not red-hot.

2. File the Point to a Smooth Surface (see Fig. 28)

It is not always necessary to file the point; in fact, it should be done sparingly, as filing wears away a great deal of the copper, especially if it is quite blunt. However, the point should be smooth and well shaped and, if not worn too much, it may be filed. If the copper has been worn

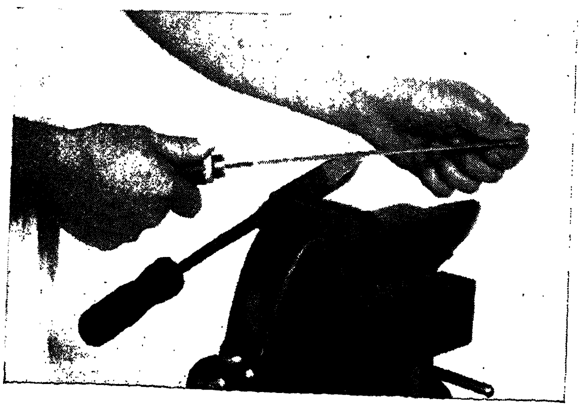

Fig. 28. Filing a copper

down very much, it is advisable to heat the point and forge it to shape with a hammer on an anvil. A loosened copper tip can also be tightened with a few blows of the hammer. Soldering coppers, like lead pencils, should be kept sharp to do good work. Figure 28 shows a well-shaped point.

3. Tin the Copper

Melt some solder with the hot copper, allowing it to drop in a hole in a cake of sal ammoniac (tinning flux). Then rub the point of the copper in the molten solder that is now on the cake (see Fig. 29).

Another way of tinning the copper is by using a soldering paste or a liquid flux in place of the sal ammoniac. This will eliminate objectionable sal-ammoniac fumes. Clean the point of the heated copper by dipping it in a liquid flux or by applying a soldering paste. Rub the cleaned copper on a scrap piece of tin plate adding solder enough to tin the point.

4. Reheat and, if Necessary, Continue the Tinning

When reheating a copper, do not allow it to get red-hot. Every time you forget and allow the copper to get red-hot, the solder burns off and it must be tinned again. As soon as the copper has a uniform coating of solder you are ready to begin soldering. The coating of solder on a reheated copper is always quite dull. This can be made bright and clean by dipping the point in a solution of sal ammoniac. Such a solution can be 1 part of sal ammoniac to about 40 parts of water, and keeps best in an earthenware jar. If a dipping solution is not available, the point can be wiped bright and clean with a damp cloth. It is well for the beginner to have his first job of tinning a copper checked by an expert.

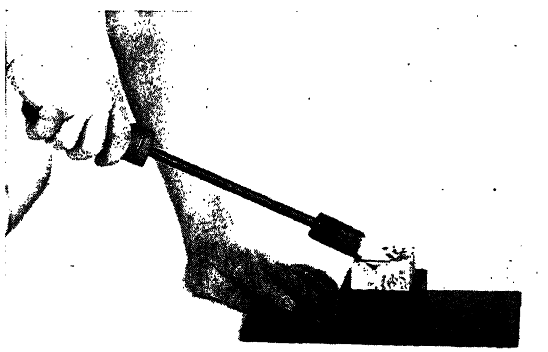

Fig. 29. Tinning a copper on a cake of sal ammoniac

5. Tin a Copper for Soldering an Overhead Seam

Tin only one side of the point of the copper. If the other sides are left rough and untinned the solder can be confined to the upper side of the copper. Such a copper is especially handy for soldering any overhead seams and electrical joints.

6. Tinning the Soldering Copper at Home (see Fig. 30)

When the above methods for tinning a copper are not available at home, the following is suggested. Take a soft brick and make a small hole in the largest surface of it. Then rub the heated copper first in rosin and then in brick dust in the hole of the brick. If you rub the point of the copper hard, the brick dust will scour it bright and the rosin will coat it so that no air can oxidize the copper. If you now melt some solder in the hole, the solder will readily stick to the copper and tin the point.

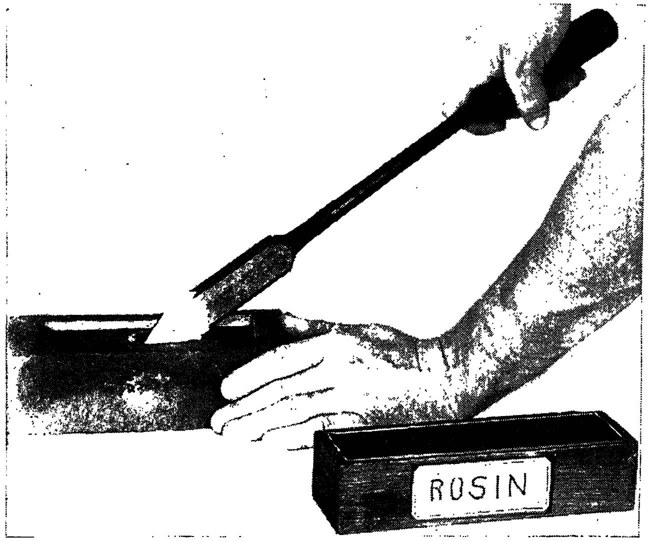

Fig. 30. Home method of tinning a copper on a brick

Rubbing the point of the copper back and forth on a bit of soldering paste spread over a piece of tin will also accomplish the purpose.

STUDY QUESTIONS:

1. Why make the soldering point out of copper?
2. How may the soldering copper be heated?
3. How hot should a soldering copper be?
4. When is a copper filed?
5. What flux is generally used when tinning a copper?
6. State a procedure for tinning the copper.
7. What is the effect of overheating a tinned copper?
8. What is the use of a dipping solution or a damp rag?
9. When should the copper be tinned on one side only? Why?
10. How may a copper be tinned at home?

Unit 5

TO SOLDER THE COMMON METALS

Soldering is the process of joining two pieces of metal by the use of hot, melted solder. The solder must always have a lower melting point than that of the metals to be joined. When the solder melts at a temperature below red heat, the process is called "soft soldering." The common soft solder is composed of 50 per cent lead and 50 per cent tin. This composition is referred to as "half-and-half" solder. Solder is marketed in 1-lb. bars, about 12 in. long, or in the form of wire wound on spools. Wire solder with a flux of acid or rosin in the core also is manufactured. This is handy for shop or home use.

When the temperature necessary to melt the solder is above a red heat, the process is called "hard soldering." Since hard soldering cannot be done with a soldering copper, the process is not described in this unit (see Unit 26).

The mechanic solders a joint to hold it in place, to increase its strength, or to make it leakproof. The electrician solders a joint to make and keep it a good conductor of electricity. The common metals soldered are: iron, tin, copper, brass, and galvanized iron. For the process of soldering aluminum, see Unit 6.

A flux is a chemical which aids in making solder stick to metal. The common fluxes help to clean the metal surface as soon as they are applied. They also tend to keep the metal from oxidizing (corroding) while the soldering is in process. Rosin, a flux, does not help to clean the surface, but prevents oxidation during soldering.

Tools: Soldering copper; furnace; acid swab (brush); and file.

Materials: Metal to be soldered; proper flux; solder; asbestos or marble slab.

METHOD:

1. Use a Well-Tinned Copper (see Unit 4)

2. Prepare the Seam or Joint to be Soldered

If there is any dirt or grease on the seam, remove it thoroughly because solder will not stick to a dirty surface. If the metal is black iron, remove

the oxide with a file or other abrasive, or with raw dilute sulphuric acid.

Place the pieces to be joined in the proper position. If the seam must be supported on something, use a marble or asbestos slab. These materials will not burn nor conduct the heat from the seam.

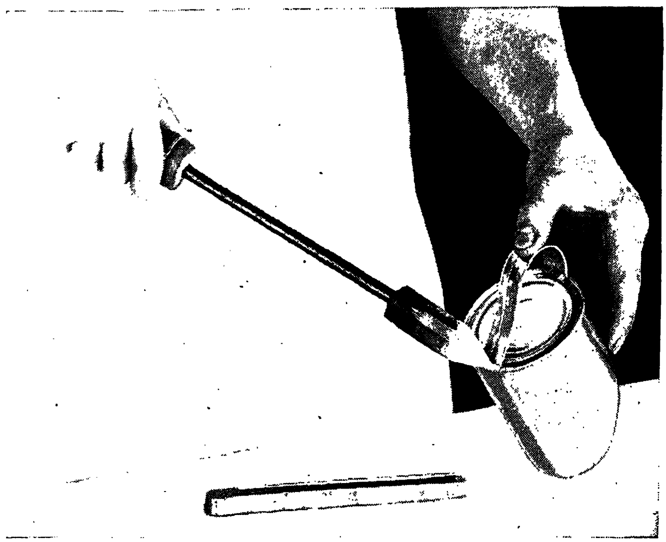

Fig. 32. Soldering a handle to a sugar scoop

3. Arrange to Hold the Seam

If the seam is not folded or riveted together, some method of holding it securely in place is necessary. On small projects the joint may be held together with the hands (see Fig. 32). On large pieces the tang of a file often is used to press the seam together with one hand, while the soldering is done with the other hand (see Fig. 33).

4. Select and Apply the Flux (Omit This Step if a Flux-Cored Solder is Used)

The flux usually is applied with a brush onto the seam to be soldered. For general work, a commercially prepared noncorrosive flux is quite convenient. A number of these commercial fluxes serve very well for the common metals.

Many noncorrosive paste fluxes for general use are commercially prepared. They are available in small convenient tins.

Zinc chloride is a common flux for iron, copper, brass, and galvanized iron. It can be made by adding small pieces of zinc to muriatic acid until

no more dissolves. This flux, if used, should be washed off later with water, as it will cause corrosion if left on the joint.

Powdered rosin is recommended as a flux for roofing tin and new tin plate. It will not cause corrosion if left on the joint.

5. Tack the Seam (if necessary)

When it is necessary to solder a lap seam as shown in Figure 33, tacking is recommended. This is done by picking up a drop of solder

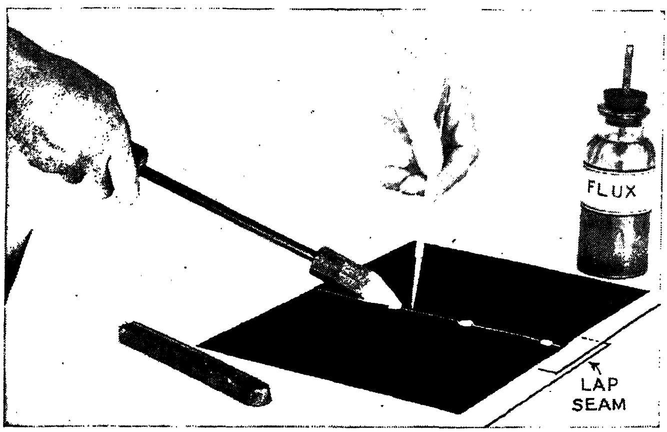

Fig. 33. Using a file to hold a seam together for tacking

with the point of the copper and then applying it to the seam. Apply drops of solder at regular intervals along the seam as shown in Figure 33. This will hold the seam in place for final soldering.

6. Solder the Seam

Pick up some solder with the tip of a hot, well-tinned copper, and lay one of the beveled sides of the copper on the seam. Hold the copper so the point will extend beyond the edge of the seam where the solder must enter (see Fig. 34). Keep the copper stationary on the seam until the seam becomes as hot as the molten solder, which is when the solder begins to flow over it. As soon as the solder flows freely into the laps, move the copper very slowly along the top of the seam. Feed some solder to the point of the copper, as needed, by applying from above with a bar of solder or feeding from behind with a piece of wire solder (see Fig. 34). Add additional solder as needed and continue to move the copper slowly toward the end of the seam. Solder as much as possible with one heat of the copper. A good job shows the seam thoroughly covered and the surface of the solder shiny and smooth.

When the copper will no longer melt solder freely, reheat or change it for a hot one. Begin soldering where you left off, but do not move the copper along the seam until it has remelted the solder in that area. Then proceed slowly as before.

7. Sweat a Seam

A very thorough method of soldering a lap seam is called "sweating." To do this, tin both the surfaces to be joined with the soldering copper. Then place the tinned surfaces together and apply the hot copper from

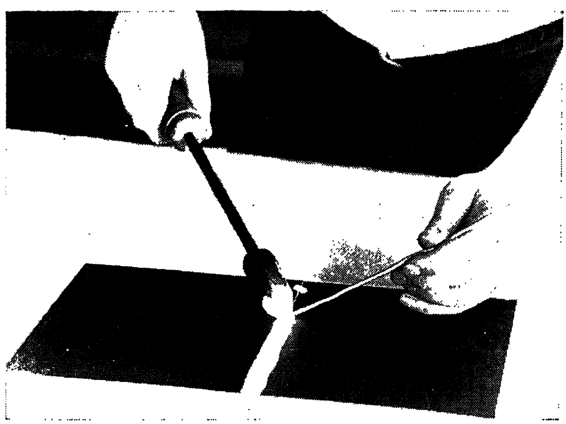

Fig. 34. Feeding solder to the tacked seam as the copper moves along

above. When the hot solder begins to run out from between the joint, it is said to be sweated. A file tang is useful here to hold the sweated joint in place after the pressure of the copper is removed. Sweating is a very efficient method for applying patches to vessels containing holes of large diameter.

8. Solder a Locked or Grooved Seam

The locked or grooved seam is described in Unit 9. Such a seam is already held tightly together and needs no tacking or additional methods to hold it in place while being soldered. Just apply the tinned copper over the seam and add solder from a bar or wire as the tip is moved along slowly (see Fig. 35).

9. Solder a Hole in a Vessel

Small holes in metal containers can be soldered as follows: Thoroughly clean around the hole for a distance of ¼ to ½ in., and add the flux suitable for the metal. Pick up some solder with a well-tinned copper,

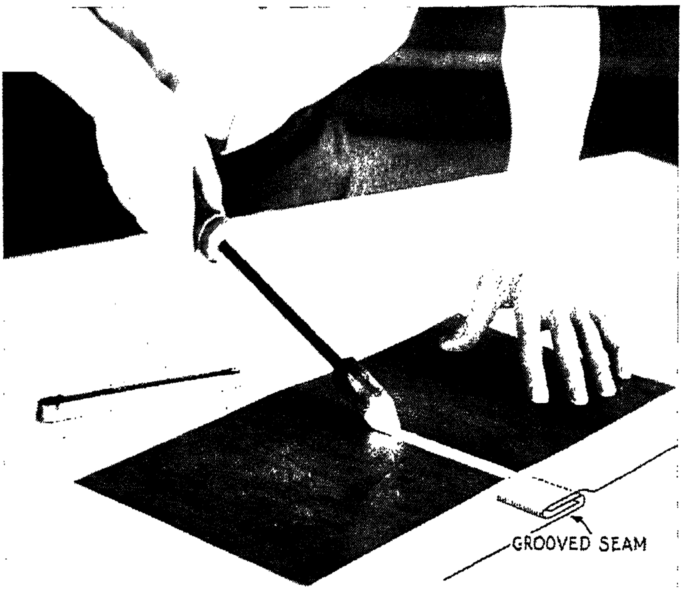

Fig. 35. Soldering a grooved seam

and apply it to the edge around the hole. Move the copper back and forth so as to tin the surface all around the hole. Finally, close the hole by sliding the copper over it. If the surface around the hole is well-tinned, the hole can be covered successfully. If the hole fails to close, add additional solder and try again. Continued failure may necessitate the adding of a patch which can be applied by sweating, as described in the foregoing.

STUDY QUESTIONS:

1. What is soft soldering?
2. In what form is solder marketed?
3. What is a handy solder for shop or home use?
4. What metals are commonly soldered?
5. Why must a joint be free from dirt for soldering?
6. What is the recommendation for cleaning when soldering black iron?
7. What is a common flux?
8. What is the objection to zinc chloride as a flux?
9. What flux is recommended for bright tin?
10. When and how is a seam "tacked"?
11. How would you sweat on a patch?

Unit 6

TO SOLDER ALUMINUM

The process of soldering aluminum and the solder used are somewhat different from that used in soldering other metals. A special solder and flux or a special-fluxed solder is necessary in order to get the solder

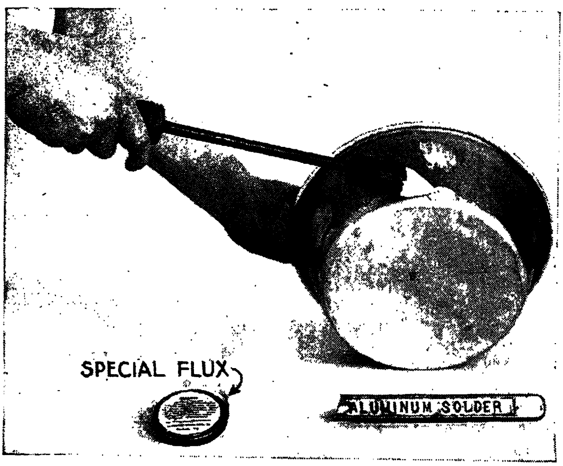

Fig. 37. A special flux and aluminum solder is used to solder aluminum

to take hold on aluminum (see Figs. 37 and 39). The regular soldering copper can be used for the work, but it is best to use one reserved for aluminum.

New aluminum solders have been made that contain the flux in combination, and they are referred to as "fluxed solder." If the solder is not already fluxed, a special flux is always supplied with the special aluminum solder.

In learning to solder aluminum you are cautioned to follow all directions carefully, and make special note of instructions for any special brand of solder used. This is one of the most important rules.

White metal, pot metal, and die-cast products can sometimes be

soldered with special aluminum solders. Note carefully any directions for this with the special solder used.

Tools: Soldering copper; furnace; wire brush; file or scraper.

Materials: Aluminum to be soldered; aluminum solder and special flux; or special-fluxed aluminum solder (with flux in combination).

METHOD:

1. Obtain Aluminum Solder and Flux

A special solder is necessary for aluminum, so do not attempt to use any other. Numerous mixtures have been worked out for such solders, but some reliable commercial brand is recommended for general soldering.

Several fluxed solders, which are prepared combinations containing both solder and flux, are on the market. Such a combination contains a flux to help prevent oxidation. Carefully note any special directions given by the manufacturer for application of the fluxed solder used.

With other aluminum solders use the special flux which is always supplied with the particular aluminum solder (see Fig. 37). Any directions that are given by the manufacturer as to the application of this solder should be carefully noted. Do not attempt to use anything but aluminum solder and the special flux recommended for aluminum.

2. Prepare the Surface

The surface to be soldered must be entirely clean and slightly roughened by scraping. Be sure to remove all grease before scraping. Scrape or

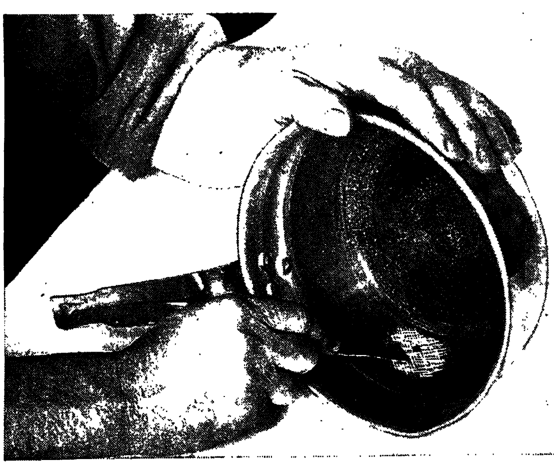

Fig. 38. Scratching the surface around the hole with a wire brush or a file

scratch the surface with a wire brush, a file, or some scraping tool until it presents a rough appearance (see Fig. 38). The roughing process is continued until all the smooth and shiny surface disappears. This roughing process is very necessary for the successful soldering of aluminum. Clean the surface with a wire brush or file, regardless of whether the material is new or old.

3. Tin the Copper

Use a heavy copper — about 3 lbs. or even heavier. It is best to reserve a copper for aluminum soldering only. If an old copper is used, file the faces thoroughly to remove the regular tinning. It is better, however, to use a new copper that has not been tinned with ordinary solder. Heat the copper and rub on a "fluxed solder," or use the special flux supplied with the special solder to tin the point. The copper should be hot enough to melt the aluminum solder and cause it to flow freely. If the solder fails to flow freely, reheat and try again.

4. Heat the Copper for Soldering

For soldering aluminum the copper must be hotter than for ordinary work, because it takes a higher temperature to melt aluminum solder, and then, too, the aluminum conducts the heat rapidly away from the copper. Heat the copper almost to a red heat, at which temperature the aluminum solder should flow freely on the work.

5. Solder a Hole

Add a flux around the hole (if recommended), and apply the extra-hot, well-tinned point to the surface to be soldered. If you are using "fluxed solder" no additional flux is necessary. Add some solder to the heated surface around the hole and, when it flows freely, tin completely around the hole. An old hack-saw blade or stiff iron wire may aid to rub in the solder. The rubbing process helps the solder to take hold and thus tin the surface. Lastly, try to cover the hole with a quick sliding movement of the copper over it.

6. Sweat a Joint

One method is to tin all the surfaces that are to be joined. Since aluminum carries away heat so readily, it is advisable, if possible, to back up flat pieces with asbestos, marble, or other nonconductors of heat. Tin both surfaces to be joined as described in Step 5. Lay the two tinned surfaces together and heat with a hot copper or over a flame. When the solder has softened on both pieces, remove the heat and hold them together tightly with a piece of iron. The tang of a file or a broken hack-

saw blade is often used for this. Hold together until the solder sets. Then cool, wash, and examine the joint to see if it is thoroughly united.

Another method of sweating a joint is to use an aluminum solder that has a separate flux. Place the flux between the two pieces, and heat it with a hot copper or with a gas flame. When the flux begins to burn away or boil, add some solder. Heat until the solder flows in and completely seals the joint; then remove the heat and hold the jointed parts firmly in place until the solder sets. In some cases this may prove to be a better joint than one made by tinning each piece separately.

7. Patch a Hole by Sweating

First tin the patch which is to be fastened to the main object, then let the patch cool while tinning the object to be patched (see Fig. 39).

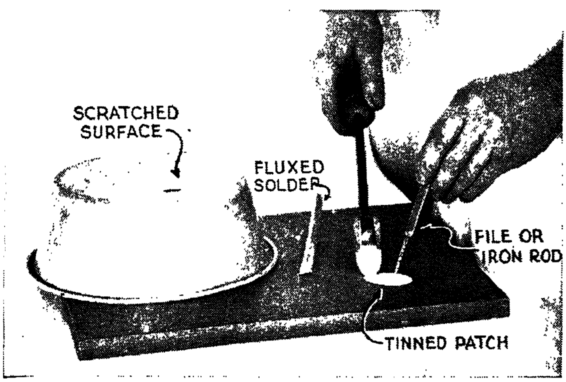

Fig. 39. Applying a patch to an aluminum dish

When cleaning around the hole be sure to clean and scratch an area larger than the patch itself. This will insure good soldering at the edges of the patch. When the main object is tinned and still hot, place the patch over the hole and sweat together. Hold the patch in place until the solder sets. By this method the main object is heated only once, and the tinning and sweating process may be accomplished with one heating of the copper.

Patches may also be applied by using the second method of sweating a joint as described in Step 6.

STUDY QUESTIONS:

1. Will ordinary solder adhere to aluminum?
2. What kind of solder is recommended for work on aluminum?
3. What is a "fluxed solder"?

4. What is most important when using an aluminum solder?
5. How does one prepare the surface for soldering aluminum?
6. What size copper is recommended for the job?
7. If an old copper is used, what precautions are recommended?
8. How hot should the copper be for soldering aluminum?
9. Give the order of sweating a joint when applying a small patch to a vessel.

Unit 7

TO BEND (BRAKE) SHEET METAL

The metalworker often finds it necessary to bend flat pieces of sheet metal at sharp angles. This operation also is referred to as "braking." Bending or braking is useful for forming objects where a single piece oi material makes more than one side of an object. We brake metal also to make hems, seams, or joints.

One method of bending frequently used is done by hand with the use of a stake. Its operation is explained in Method A following.

Narrow portions of a sheet of metal are bent with the handy seamer, which is a small tool designed for this work. Its use is fully described in Method B.

A bench vise and a mallet can be used to make sharp bends in small pieces, as directed in Method C. Several vise substitutes allow larger pieces to be bent by this method.

A bar folder is a special machine made for bending narrow folds on sheet metal. An all-metal bar folder is shown in Figure 47. A roofing folder, used for the same purpose, is made partly of wood and is simpler and less expensive. The operation of the two folders is similar, as shown in Method D. If your shop does not possess a folder, use the hand methods suggested.

Material: Sheet metal to be bent.

METHOD A: To Bend Over a Stake

Tools: Stake; mallet (if desired).

Small pieces of thin metal can be bent by hand (see Fig. 42). Use the sharp arris (edge) of a hatchet stake or any substitute for the hatchet stake that possesses a sharp arris. Place the line for the bend directly over the arris, with the part to be bent down overhanging or projecting. Then hold the metal securely as the overhanging part is bent down by hand. Light blows with a mallet will aid to make the bend sharp rather than rounded. A metal hammer used on the bend is likely to stretch it out of shape; therefore the mallet is recommended.

The hatchet stake also is convenient for making bends in the center of wide sheets if the metal is not heavy.

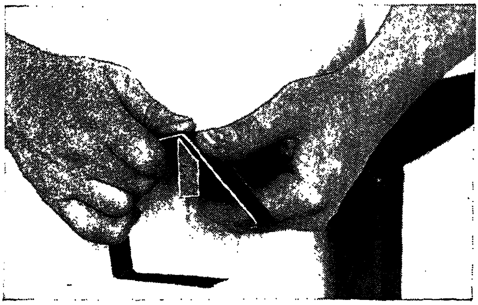

Fig. 42. Braking a cooky cutter by hand over a "hatchet" stake

METHOD B: To Bend with a Handy Seamer

Tool: Handy seamer.

A handy seamer is a small tool which is useful for bending over narrow portions that would be difficult to do by hand. Two adjustable screws determine the width of the portion to be bent. These should be carefully set and locked so that one jaw of the seamer will line up exactly with the line at the determined bend. Clamp the jaws together tightly, and bend as shown in Figure 43. When the metal to be bent is longer than

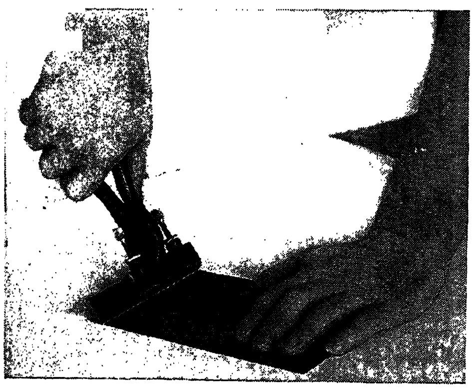

Fig. 43. Using a handy seamer to bend over narrow portions

the seamer, move the seamer along the piece, bending a short length at a time until the entire edge is bent. If the piece needs more bending, go over the entire length again. Bending gradually helps to eliminate inaccuracy and kinks.

METHOD C: To Bend with a Vise and Mallet

Tools: Mallet and vise or vise substitutes.

A metal vise is convenient for bending small pieces at right angles.

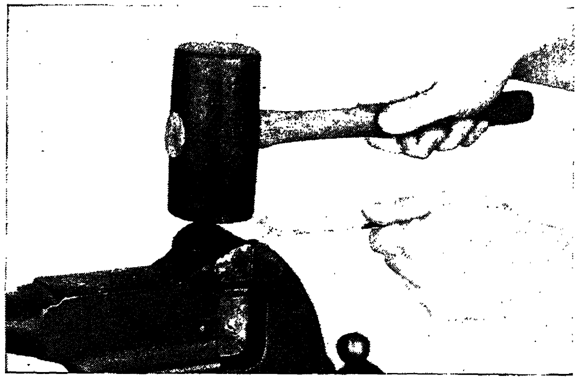

Fig. 44. A vise and mallet are useful for bending small pieces at right angles

Tap along the bend (brake) with a mallet to make the bend sharp (see Fig. 44). If the vise jaws are rough, however, the work will be marred. This may be avoided by covering the rough faces of the jaws with pieces of scrap metal before fastening the work.

Two angle irons set in the vise jaws will allow wider pieces of metal

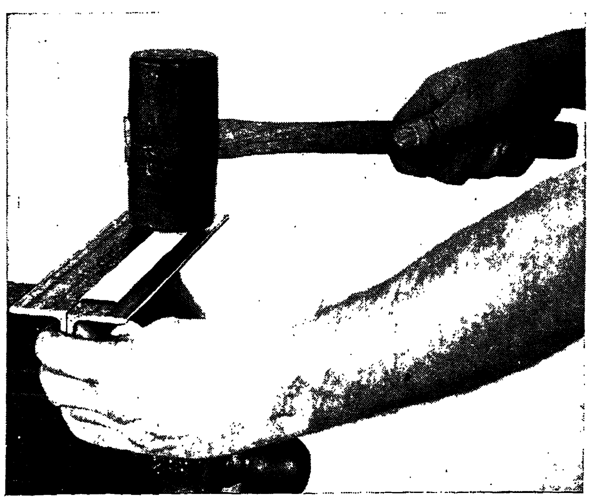

Fig. 45. Using two angle irons to widen the vise jaws for bending

to be bent in this manner (see Fig. 45). They will also prevent the metal from being marred by rough jaws.

Figure 46 shows a similar method for bending over the narrow edges of long pieces of metal. A strip of wood and a table top substitute for

the jaws of the vise. C clamps hold the strip of wood and the metal in place. This method is useful for making large boxes by hand.

A large, heavy machine called the "cornice brake" would be used to do this job in a commercial shop.

Fig. 46. Bending long pieces by hand methods

METHOD D: To Bend with a Bar Folder (see Fig. 47)

Tool: Bar folder.

Bar folders are bench machines used to bend over narrow edges on metal. A common type 30 in. long will make bends or folds up to 1 in. in width. There are two adjustments on the typical bar folder, one of which regulates the width of the bent-over portion and the other the sharpness of the bend.

The width (or gauge) of the bent-over portion (often called the fold) is regulated by a gauge knob on the side of the machine toward you. To regulate, loosen the locking screw, and turn the gauge knob to the right or left. An indicator which moves over a 1-in. scale tells the width of the fold. Never try to fold less than ⅛ in. Tighten the locking screw when the desired adjustment is made.

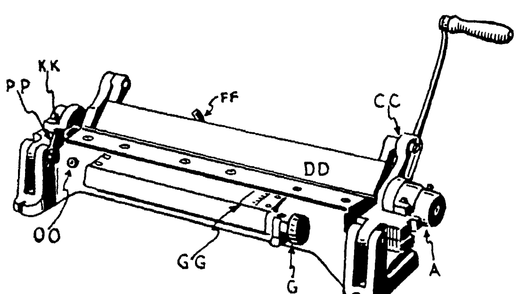

Fig. 47. Bar folder. CC, folding bar; GG, gauge indicator and scale; G, gauge knob; OO, lock screw for locking gauge after setting to scale; FF, lever to regulate sharpness of bend; DD, bending wing; PP, stop gauge, 90 deg.; KK, stop gauge, 45 deg.; A, adjustable stop gauge

The sharpness of the bend is regulated by a lever on the opposite side of the machine. This lever raises or lowers the bending wing. Raise the lever to make a sharp bend and lower it to make a rounded bend. Do not raise the wing too high. A locking screw operated with a T wrench holds the lever in the desired place. Loosen and tighten this screw for every adjustment, and use a piece of scrap metal to test each adjustment.

To make a fold, slide the edge of the metal into the machine, and hold it firmly with the left hand against the gauge under the beveled blade while you pull the wing up and toward you with the right hand. Stop the wing at the desired angle of the bend. Keep the left hand still holding the metal and return the wing to its starting position. Remove the piece and check to see if the bend is correct. If not, readjust and test again. Special stop gauges at the left are useful for duplicating bends at these angles. An adjustable collar on the right side of the folder can be set to duplicate any desired angle.

When beginning to make a fold, if the metal bends easily and then suddenly requires considerable additional pressure, stop the procedure. In this case the wing has probably been raised too high, and continued pressure might injure the machine. Lower the wing slightly and test again. When the wing is in a vertical position its distance from the stationary blade should at least equal the thickness of the stock. This will give a sharp bend. When a more rounded bend is desired it should be much farther away. This rounded bend is desirable when reinforcing an edge with wire.

6. Hem an Edge

The sharp, rough edges of metal are seldom left exposed in a project. If such an edge is folded (turned all the way over), it is called a "hem." A hem gives a smooth, rounded edge, offers protection against the otherwise sharp metal, and also stiffens the entire edge. If a double fold is made, the process is called "double hemming." A double hem hides the rough edge entirely and also gives added stiffness (see Fig. 48).

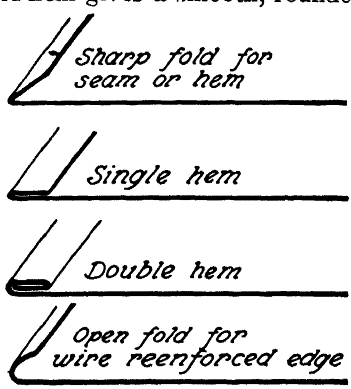

Fig. 48. Common folds used on the edges of sheet metal

To hem an edge on the bar folder, fold a portion all the way over. Remove from the folder, and then mash the fold flat under the bending wing. To make a double hem, fold and flatten again. Bar folders will only mash down such hems in the light gauges of metal.

STUDY QUESTIONS:

1. What is the metalworker's term for bending a piece of metal?
2. What are some of the hand tools used to bend metal?
3. Why use a mallet rather than a hammer to aid in bending metal?
4. What is the use of a handy seamer?
5. What is a hem? A double hem? Their use?
6. What is the use of the bar folder?
7. How is the bar folder operated?

Unit 8

TO FORM CURVES, CYLINDERS, AND CONES IN SHEET METAL

Many metal containers are made of curved parts, the cylinder and cone being the most common shapes. The extensive use of curves in metalwork can be seen by referring to any catalog of cooking utensils or a general hardware catalog. It might be interesting, also, to note the numerous uses of curves in the many electric-light fixtures which are of metallic construction.

Tools: Sheet-metal stakes or substitutes; mallet.

Material: Sheet metal to be shaped.

TO FORM CURVES IN SMALL PARTS

Miscellaneous curves can be formed over round stakes. A number of stakes are shown in Figure 50. All of these stakes are useful in forming curves in metalwork projects. Select a stake of suitable curvature and

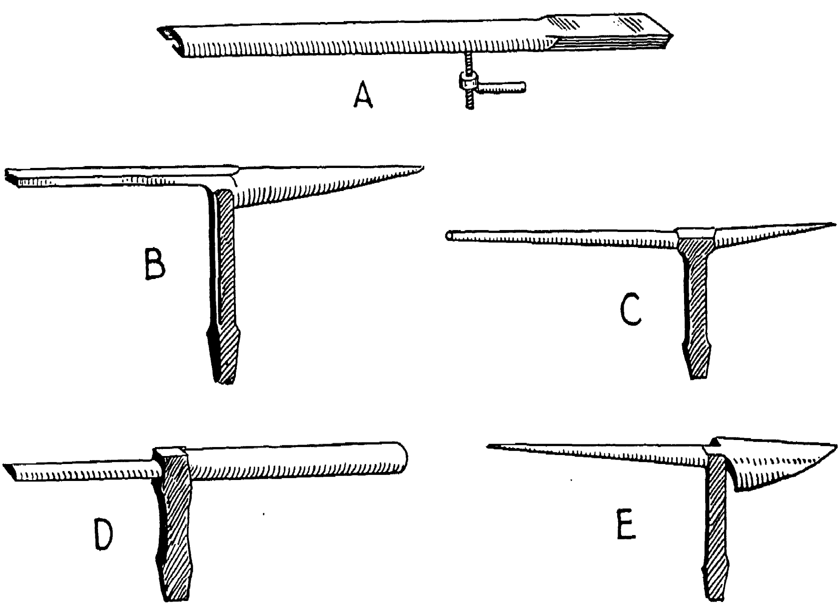

Fig. 50. Some useful stakes for forming curves. A, hollow mandrel; B, beakhorn; C, candle mold; D, conductor; E, blowhorn

arrange to hold the stake securely. Figure 51 shows several metalworker's bench plates which are convenient for holding the regular metal stakes. Pipes and rods of different diameters, clamped in the pipe jaws of a vise, make good substitutes for stakes if none are at hand.

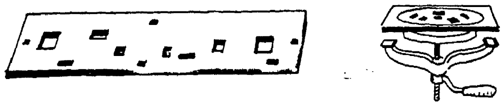

Fig. 51. Typical stationary and revolving stake holder

Figure 52 shows how to form curves for a cooky cutter. Handles for cups, containers, lids, etc., can be formed in a similar manner. To form such curves, cut out the parts to be curved and hem the edges if hemming is desired (see Fig. 48). Select the proper size stake to make the curve. Hold one end of the piece tightly to the stake with one hand and bend to shape with the other hand. If possible, make the curve with a uniform

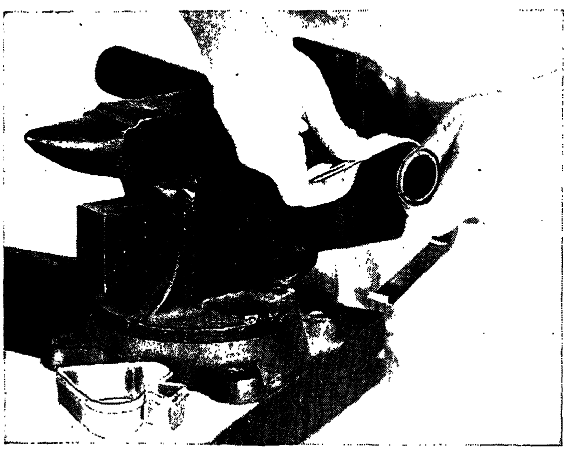

Fig. 52. Using a pipe as a stake for forming curves

motion of the hand, which will give a smooth curve. Do not use the mallet for making small, curved pieces in light or narrow material, because pounding tends to dent the metal.

TO FORM CYLINDERS

1. Select a Cylinder Stake or Piece of Pipe

The stake should always be smaller than the diameter of the proposed cylinder.

2. Fold the Edges (if necessary)

If necessary, fold the edges for any folded seam planned to hold the cylinder together (see Fig. 59). The grooved seam often is used for this purpose, and if a lap seam is used no folding is necessary.

3. Brake the Edges

The hardest place to form a curve is at the edges of a pattern. To do this, place the metal sheet over a round stake so that the edge is slightly

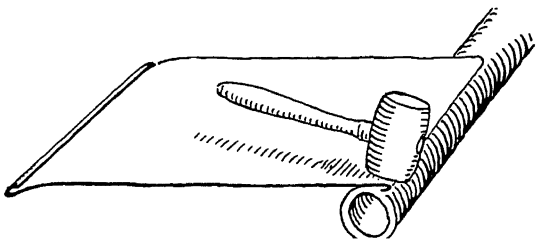

Fig. 53. Hand method of beginning a curve at the edge of a piece of metal

beyond the center line of the top of the stake. Then strike the metal with a mallet to begin the bending of the curve. Do this on both edges, being careful not to flatten any folds that are to be used for seaming (see Fig. 53).

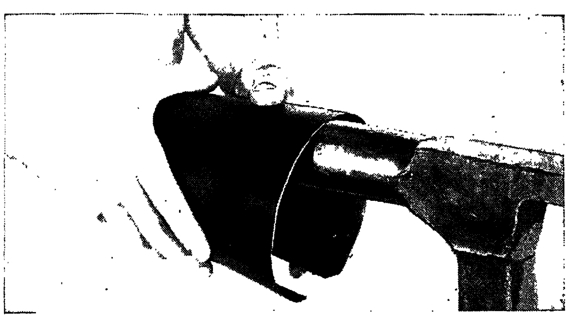

Fig. 54. Forming a cone-shaped vessel on a beak-horn stake. Cylinders are formed in a like manner

4. Form the Cylinder

Grasp the metal in both hands, and gradually bend it over the stake (see Fig. 54). Stop when the diameter is equal to that desired. If a folded or grooved seam is used for fastening, bend so the folds hook tightly

in place. Even for a lap seam the metal can be formed so that the tension of the curve will hold the joint tightly together.

TO FORM A CONE

1. Use a Blowhorn or Beakhorn Stake (see Fig. 50)

2. Form and Brake the Edges

Form the edges before beginning to form the curve. Brake the edges with a mallet, as shown in Figure 53.

3. Form the Cone (see Fig. 54)

Grasp the piece in both hands and bend the metal partly down over the stake. After a partial bend is made, move to a new radial line of the layout directly over the center line of the stake, and bend some more. Make every bend from a new radial line until the cone is finally closed. Remove the cone from the stake and study the shape as to regularity. To get the proper curve, carefully reshape any portions on the stake.

STUDY QUESTIONS:

1. Is metal quite easily shaped to form curves?
2. Name several metal objects that contain curved parts
3. Name several metalworking stakes.
4. What make good substitutes for stakes?
5. Why form a curve with a uniform motion?
6. What part of a curve is hardest to form?

Unit 9

TO MAKE A FOLDED OR A GROOVED SEAM

Seaming is the process of joining pieces of sheet metal at the edges, and is one of the most important operations in metalwork. The common types are the lap seam, the folded seam, and the grooved seam.

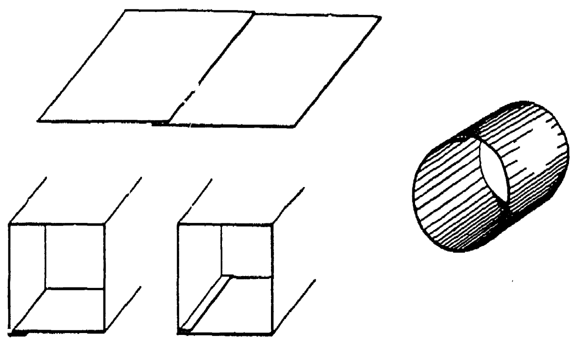

Fig. 57. Typical lap seams and uses. All lap seams must be soldered or riveted for fastening

The lap seam is just the overlapping of the metal (see Fig. 57). It is used in the simplest construction and is usually riveted or soldered to hold it in place. A common width for a lap seam in thin metal is ¼ in., but other widths also are used.

The folded and grooved seams are very much alike, and the first steps in construction are exactly the same (see Fig. 58). It is the final operation that distinguishes these two seams. While the folded seam is hammered flat with a mallet, the grooved seam is grooved with a grooving tool. The folded seam is used extensively in laying flat metal roofs. This seam does not lock itself and it usually is soldered to hold it in place.

The grooved seam is more commonly used than the folded seam. It is almost as easily made and requires no soldering or riveting to hold the joint securely. The method of grooving locks a seam tightly in place. It is used to join flat pieces of metal, to join round or square pipe, and to connect the sides of conical or cylindrical vessels. Grooved seams, 3/16 and ¼ in. in width, are commonly used in typical construction. Wider

seams may be used on large containers to give additional stiffness to the project. Sometimes additional seams are used for this purpose.

Tools: Bar folder; hand groover; hammer; mallet.

Material: Sheet metal to be seamed.

METHOD:

1. Add Metal for the Seam

Figure 58 shows a folded and a grooved seam. Note there are four layers of metal at the seam. Additional metal, equivalent to three times

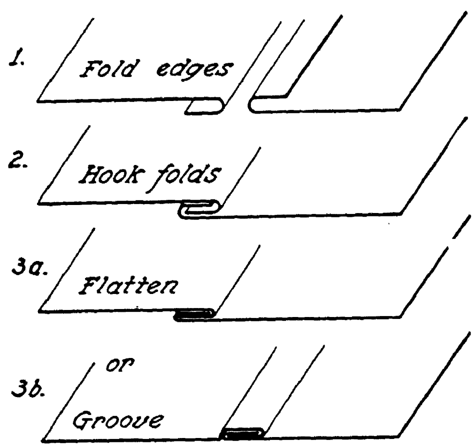

Fig. 58. Steps in making folded seam — 1, 2, 3*a*; grooved seam — 1, 2, 3*b*

the width of the seam, must be added to allow for this joint. One half of this usually is added to each side of the pattern. The added material for the seam always must be parallel to the pattern outline. Example: For a ¼-in. seam, approximately ¾ in. of metal must be added to the pattern. One half of this, or ⅜ in., is added to each side of the pattern for the seam.

On 24-gauge or lighter sheet metal, nothing is added for thickness. On metal heavier than 24-gauge, add three times its thickness to the seam.

2. Fold the Edges

This is best done on the bar or roofing folder. If hand methods are necessary, see Unit 7. Set the gauge on the bar folder to the desired width of the seam, and fold. Note that one edge is folded from one side and the other from the opposite side of the piece (see Fig. 58). This last order of folding is especially important when forming a cylinder or any enclosure made from one piece (see Fig. 59).

3. Form the Piece of Metal (if necessary)

If the seam unites the metal to make a container, it must be formed before it can be hooked together (see Unit 8 on forming).

4. Hook the Folds

Hook the folds to form the seam as shown in 2, Figure 58.

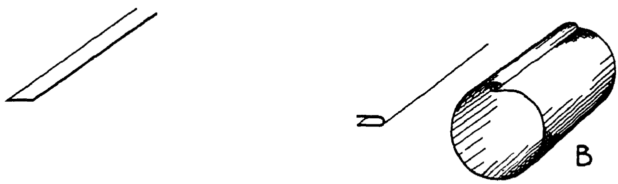

Fig. 59. A, metal folded from opposite sides for folded or grooved seam on cylinder. B, cylinder formed and folds of seam hooked

5. Make a Folded or Grooved Seam

For a folded seam, the hooked folds are nammered flat with a mallet. Flatten the joint evenly over some solid surface. This seam does not lock like the grooved seam, but is usually soldered or riveted to hold it in place.

To make a grooved seam, use a hand-grooving tool. After the folds

Fig. 60. Hand grooving a seam

are hooked together, place the joint over a stake or some solid backing. Use a groover slightly wider than the width of the folds. Fit the groover over the seam at one end and strike it with a hammer. Repeat this operation at the other end of the seam. This will hold the seam in place while grooving the remaining portion (see Fig. 60).

A grooving machine is used in the commercial shop for performing this operation.

STUDY QUESTIONS:

1. What is a seam?
2. Name the common seams.
3. Where are lap seams used?
4. Where is the folded seam used extensively?
5. Where is the grooved seam used?
6. What is the rule for allowance on a folded or grooved seam?
7. When is allowance made for thickness of stock?
8. State order of making a folded or grooved seam (see Fig. 58).
9. How does a folded seam differ from a grooved seam?
10. What is the advantage of a grooved over a folded seam?

Unit 10

TO DOUBLE SEAM

As shown in Figures 63 and 64, the double seam is similar in construction to the grooved seam. The grooved seam is used to join edges on a flat surface. The double seam, however, is used to join edges at the arris (corner) of square and rectangular bodies.

Angular forms are often joined with a double seam, and the bottoms for containers are fastened to the body by the use of this seam. The double seam is very substantial and rigid, but, to make it leakproof and for sanitary purposes, it should be soldered.

Tools: Square stakes; setting hammer, mallet.

Material: Sheet metal to be seamed.

METHOD A: To Double Seam an Angular Body

1. Add Metal for the Seam

An additional width of metal must be added for the folds of this seam. Figure 63 shows the steps in making the seam, in the construction of which three thicknesses of stock are used. Add a single width of the seam to the edge making the inner fold, and twice the width of the seam to the edge forming the outer fold. The average width for a double seam is 3/16 to ¼ in.

2. Fold the Edges (see A, Fig. 63)

The folds for the seam are made before the material is shaped or formed. If a bar folder is not available, use the hand methods for folding as described in Unit 7. Fold the edge, on which the single allowance has been made, to a right angle. Fold the opposite edge of the material to the reverse side, and fold this edge completely over, but do not mash.

3. Form the Body (see B, Fig. 63)

Brake the piece as directed in Unit 7, using the hand methods described if no machines are available. The machines most frequently used for this purpose are the bar folder or the cornice brake.

4. Hook the Folds (see C, Fig. 63)

Place the container on a square stake so that the stake is directly under the portion to be seamed, and press the folds together with your hands.

5. Pinch the Fold (see D, Fig. 63)

With a pair of pliers, pinch the fold of the seam tightly together at one end. For the beginner it is advisable to pinch the fold together for its entire length.

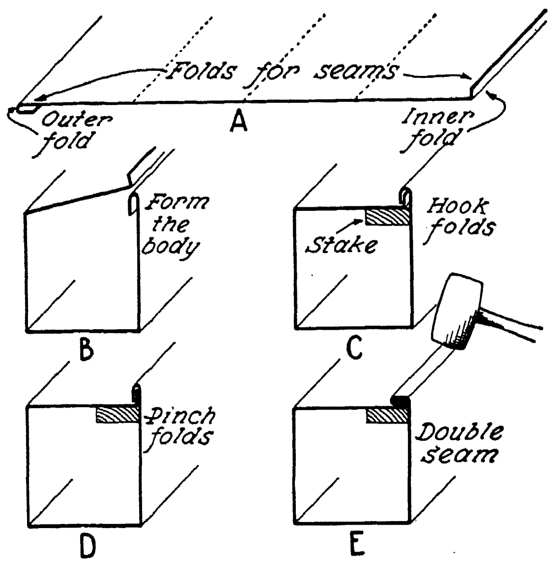

Fig. 63. Steps for making a double seam

6. Double Seam (see E, Fig. 63)

Place a square stake directly in the corner under the seam. With a mallet set down the fold against the body as shown. Start from one end of the seam, and set or fold it for the entire length.

METHOD B: To Make a Rectangular Container Using the Double Seam

1. Add Metal to the Body for the Bottom Seam

Additional metal must be added at one end of the body for the inner fold of the bottom seam. Add just the width of the seam for this purpose (see A, Fig. 64). Notching at every brake is necessary so the body can be formed.

2. Fold the Edges for the Bottom Seam

Fold the edges for the seam at right angles to the body as directed in Method A. The folds for all sides are best made in one operation, using hand methods, the bar folder, or the cornice brake.

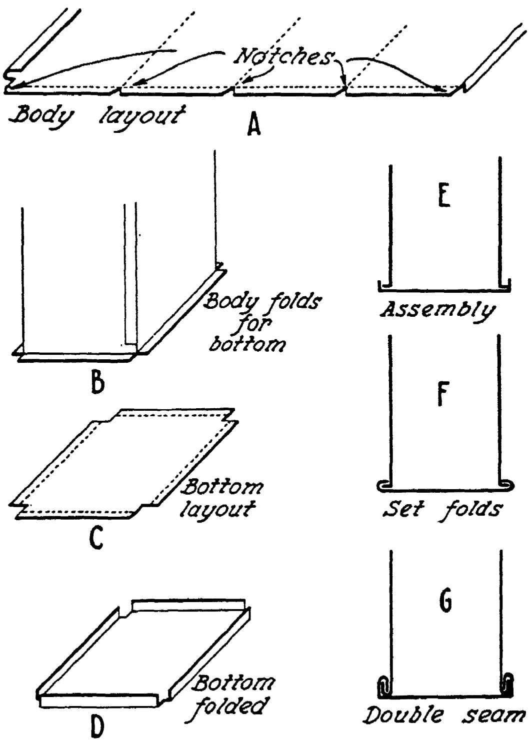

Fig. 64. Steps for double seaming a bottom

3. Double Seam the Body

Form and double seam the body as described in Method A (see B, Fig. 64).

4. Cut and Fold the Bottom

The bottom must be large enough to hook over the flanged portion of the body as shown in C, Figure 64. Measure the length and width of the container to the outer edges of the flanged portion. To this add the width of the seam all the way around. Notch the corners twice the width of the seam as shown, and fold the edges to a right angle (see C and D, Fig. 64).

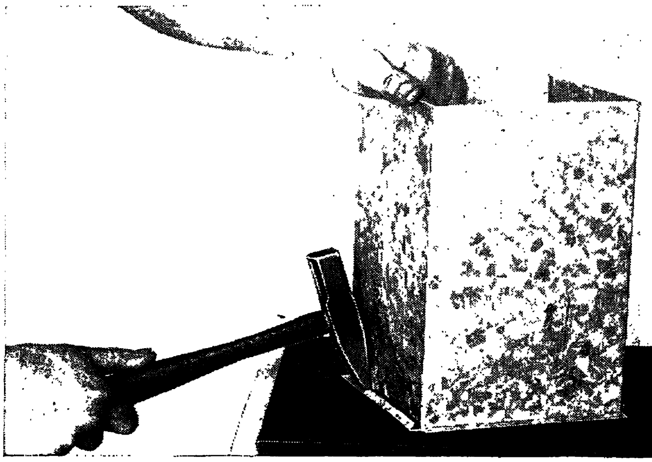

Fig. 65. Setting down the folds of a double seam with a setting-down hammer

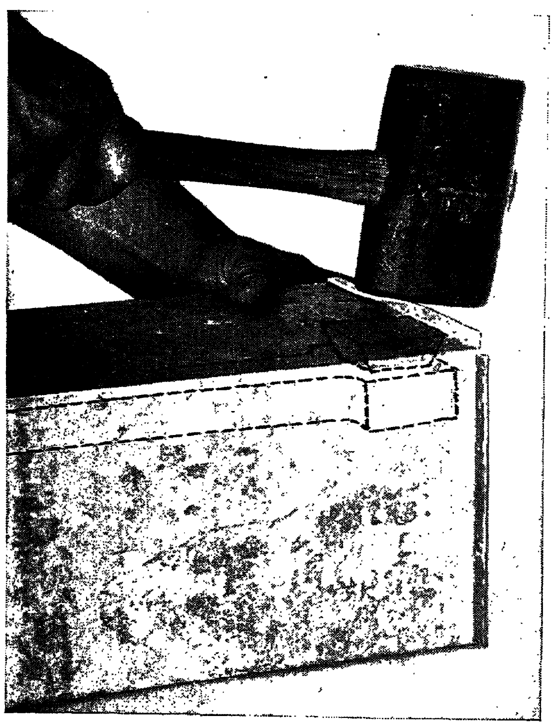

Fig. 66. Double seaming a bottom on a double-seaming stake

5. Set Down the Folds (see E and F, Fig. 64)

Assemble the bottom and the body as shown, and set down the folds with a setting hammer (see Fig. 65).

6. Double Seam the Bottom (see Fig. 66)

Place the container over the end of a seaming stake. With a mallet strike the edge of the fold at a slight angle bending it over about 45 deg. Complete the setting by hammering the seam tightly against the body as shown in Figure 66.

STUDY QUESTIONS:

1. The double seam is similar to what seam?
2. Where is the double seam used?
3. Why is a double seam soldered?
4. How much metal is added for a double seam?
5. State the steps in double seaming.
6. What hammer is used to set down a seam?
7. When is the mallet used in double seaming?

Unit 11

TO PUNCH HOLES IN METAL

Punching holes means the forcing of a tool (a punch) directly through the metal. The metal to be punched is backed up by a solid back plate of lead or wood or by a die of hardened steel. In either case, the back plate or the die holds in place the surrounding metal, while the punch forces out a metal disk of its own size (see Figs. 68 and 69).

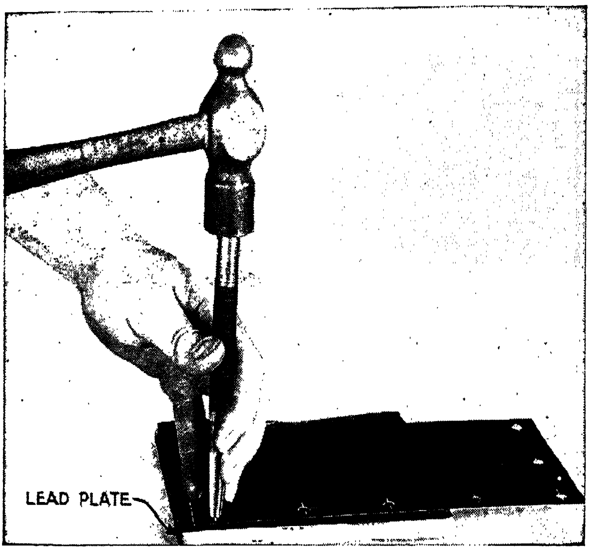

Fig. 68. Punching holes with a solid punch

Holes usually are punched in sheet metal with a solid punch and a hammer (see Fig. 68). The backing commonly used is a lead plate or the end grain of a piece of hardwood. This has been the method of punching holes in metal since early times and is still commonly used by the present-day workman (see Method A).

Figure 70 shows a tinner's hand punch. This is a very efficient tool, and is used to punch holes from 1/8 to 1/4 in. in diameter in 16-gauge iron and lighter. This punch has a die which backs up the metal, and for this reason it makes a clean hole. It is a useful tool for neat and accurate work. Similar hand punches of heavier design are manufactured for use in heavier metal (see Method B).

A bench-lever punch is shown in Figure 72. This is a much heavier machine and it is used to punch up to 3/8-in. diameter holes in soft steel of 5/16-in. thickness or less. Such a punch often is combined with a shears for cutting soft sheet steel and narrow steel bars as shown in Figure 73 (see Method C).

Material: Sheet metal to be punched.

METHOD A: To Punch Holes with Solid and Hollow Punches

Tools: Solid punch; hollow punch; lead plate or block of wood.

1. Locate the Holes

Draw center lines to locate the exact center of each hole. For holes ½ in. and larger, use compasses to outline the hole. For smaller holes, center lines should extend beyond the circumference of the hole (see Figs. 68 and 69).

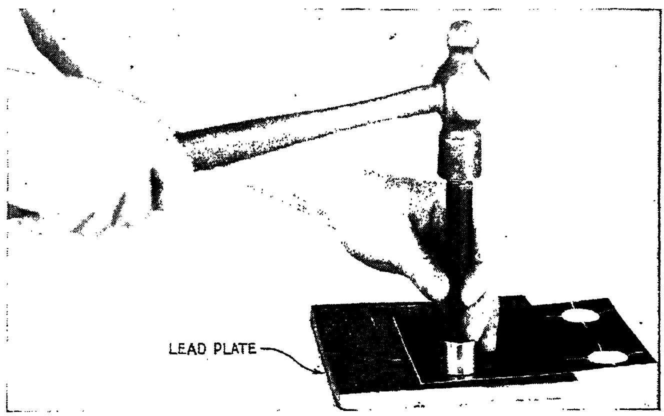

Fig. 69. Punching holes with a hollow punch

2. Select the Punch

Use a hollow punch for holes ½ in. and larger. Use a solid punch for smaller holes.

3. Select a Back Plate

A plate of lead or the end grain of a block of hard wood is used as a back plate. Never use an iron plate for backing.

4. Punch the Hole

Lay the metal flat on the lead plate or on the end grain of the hard-wood block. Carefully center the punch with one hand, and hold it tightly on the metal. Strike the punch with a heavy hammer until the hole is

cut through. Always punch a hole over a flat place on the lead plate or wood block.

METHOD B: To Punch Holes with a "Tinner's" Hand Punch (see Fig. 70)

Tools: "Tinner's" hand punch.

1. Locate the Holes

Draw center lines and center punch the location of the holes. The center-punch mark will aid in centering the tool at the exact location.

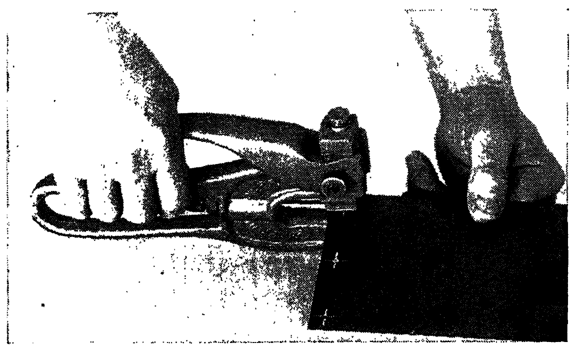

Fig. 70. Punching holes with tinner's hand punch

2. Insert Proper Dies and Punch for the Size of Hole Desired

Select and insert the proper size die and punch. Adjust the die so that the end of the punch has just entered the die when the handle is closed.

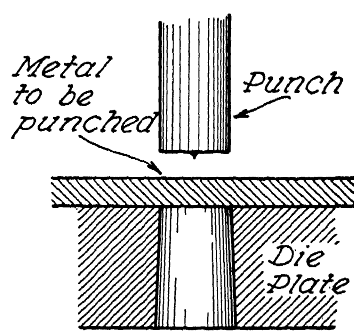

Fig. 71. Mechanism of a machine punch

3. Punch the Holes

Place the centering point of the punch in the center mark, and punch the hole. For punching a number of holes the same distance from an edge, set and lock the gauge that is specially used for this purpose.

METHOD C: To Punch Holes with a Bench-Lever Punch (see Figs. 72 and 73)

Tools: Bench-lever punch.

1. Locate and Center Punch the Holes

2. Insert Proper Dies and Punches for the Hole Desired

It is very necessary with this machine that the die and the punch are in exact alignment.

3. Punch the Hole

For punching the heaviest metal, stay bolts should be clamped in place. Inquire or see directions for the machine, and determine when stay bolts are necessary. For punching very large holes an extra stripper plate may

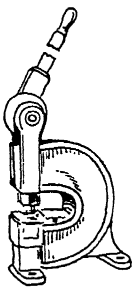

Fig. 72. A bench-lever punch

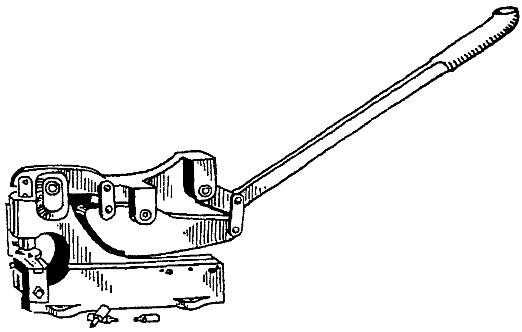

Fig. 73. Combined punch and shears

have to be added. The stripper plate is a fork which allows the punch to be withdrawn from the metal by holding the piece in place while the punch is returning on the upward stroke. When punching a heavy piece of metal, a drop of oil on the metal will make the punching easier.

Insert the metal at the proper place so that the punch centers at the desired hole. (Tighten stay bolts if they are to be used.) Pull the lever down with a quick but uniform pull. The thickness of the metal determines the force of the pull. Raise the lever slowly to pull out the punch. A gauge is also provided here for punching holes the same distance from an edge.

STUDY QUESTIONS:

1. How is metal punched?
2. What is the use of a back plate or a die?
3. Is the hand method of punching holes commonly used?
4. Why use a bench-lever punch?
5. Why center punch the location of a hole?
6. Explain how you would center a solid punch on cross lines.
7. When do you select a hollow punch? A solid punch?
8. What is commonly used for a back plate when punching by hand?
9. Why should a hole always be punched over a flat place on the back plates?
10. How can you punch a number of holes the same distance from an edge with the tinner's hand punch?
11. What is the use of the stripper plate on a punch?

Unit 12

TO DRILL HOLES IN METAL

Drilling is an operation that is performed many times by the metalworker. It is necessary to drill holes in the construction of many projects made of metal, for the purpose of fastening them with machine screws, rivets, or bolts.

Holes are drilled in metal with a common twist drill. These drills are made of tool steel, and are hardened so that they are able to cut their way into soft steel and other metals which are less hard. The common types of drills are shown in Figure 76.

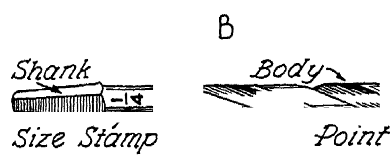

Fig. 76. A, bit-stock drill showing three main parts of every drill; B, straight-shank drill; C, taper-shank drill

The twist drill is almost always used with some type of drilling machine. The common types of such machines are described in Step 2 under Method. These machines are arranged to clamp the drill securely in a chuck and then turn it so it cuts its way into the metal. The brace, hand drill, portable electric drills, and small bench drills have small chucks permanently attached to the spindle. Such chucks are operated by merely turning with the hands. The larger bench drills are often equipped with a removable chuck of larger capacity.

The removable chucks have a taper shank attached and are used in the same spindle socket as the taper-shank drills. Such chucks are usually operated by a T-handled wrench and are used to grip the straight-shank drills up to 3/8 or 1/2 in. in diameter. When it is desirable to use taper-

shank drills direct, the chuck is removed and the shank of the drill is inserted in the spindle.

Taper-shank drills are used to drill the larger holes (see Fig. 76). They fit into the tapered socket at the lower end of the spindle, and are held in place by friction between the tapered hole in the spindle and the tapered shank of the drill. These larger drills must be run at a lower speed than the smaller-sized drills. Taper-shank drills are removed from the spindle by driving a "drift" into the slot of the spindle. The chuck is removed in like manner. The taper shanks of either chucks or drills should always be handled carefully to avoid nicking the surfaces. They should also be wiped clean before inserting into the spindle of the drilling machine.

"Feed" is the rate at which the drill is forced into the metal as it cuts the hole. It is generally measured in fractions of an inch per revolution. In the brace-and-breast drill, the body helps to exert pressure. In the hand tools and the bench drills, pressure for feed is usually applied by hand.

The following table gives the suggested speeds for some of the common drill sizes when drilling in mild steel with carbon-steel drills. The speeds recommended amount to about 30 feet per minute on the outer edge of the drill.

Size of Drill	*Speed in R.P.M.*
1/8 in.	920
3/16 in.	610
1/4 in.	460
3/8 in.	300
1/2 in.	230

Tools: Drilling tools; twist drills; center punch; hammer.
Material: Metal to be drilled; lard oil or cutting compound.

METHOD:

1. Center Punch for the Hole (see Fig. 15)

Measure carefully to locate the exact center of the hole. Holes poorly located may cause trouble when pieces are to be assembled. Center-punching helps to start the drill in the proper place.

2. Select the Drilling Tool

The following tools are commonly used for drilling metal:

Brace. Use the ordinary woodworkers' brace. A brace with a wide swing gives more power. Use a brace when plenty of room is available, when the hole is large, and drilling must be done by hand. Figure 83

shows the brace in use for countersinking a hole. When holes are drilled, the brace is used in the same manner.

Hand Drill (see Fig. 77). A hand drill is used for drilling small holes, and is convenient in places where the brace might be awkward to handle.

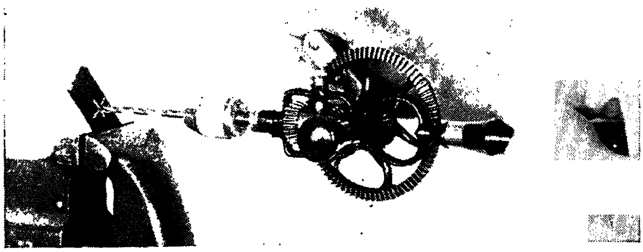

Fig. 77. Drilling with a hand drill

It is often used to drill in sheet metal when punching holes is not possible. Drills of this type have a slow and a fast speed, with a ratchet handle. Use the fast speed for small holes and the slow speed for larger holes. The ratchet is convenient for tight places. A hand drill with a breast plate is called a "breast drill."

Electric Hand Drill. When available, a portable, electric drill is convenient and rapid. Figure 78 shows a small pistol-grip type, which starts

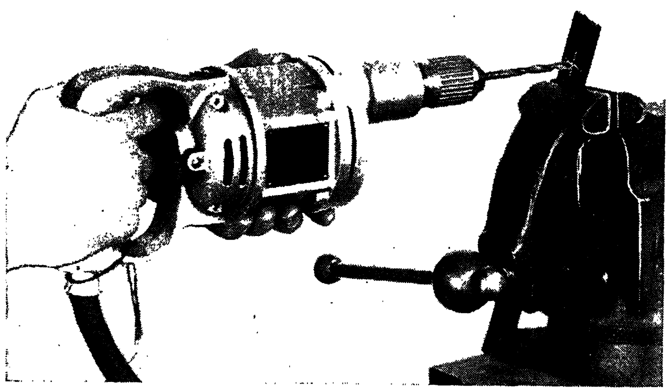

Fig. 78. Drilling with an electric hand drill

and stops with a pull on the trigger. Such drills are made to handle straight-shank drills up to 5/16 in. Heavier, electric, portable drills will handle drills up to 1 in.

Hand Bench Drill. Successful drilling in metal needs pressure. This is readily obtained by the bench drills. In the hand bench drill, the turning of the drill as well as the feed is operated by hand.

Electric Bench Drill. Convenient new types of electric bench drills are now available. Figure 79 shows such a machine, the drill of which is run by electricity while the feed is operated by hand. Many companies now furnish a stand for converting the portable electric hand drill shown in Figure 78 into a bench drill.

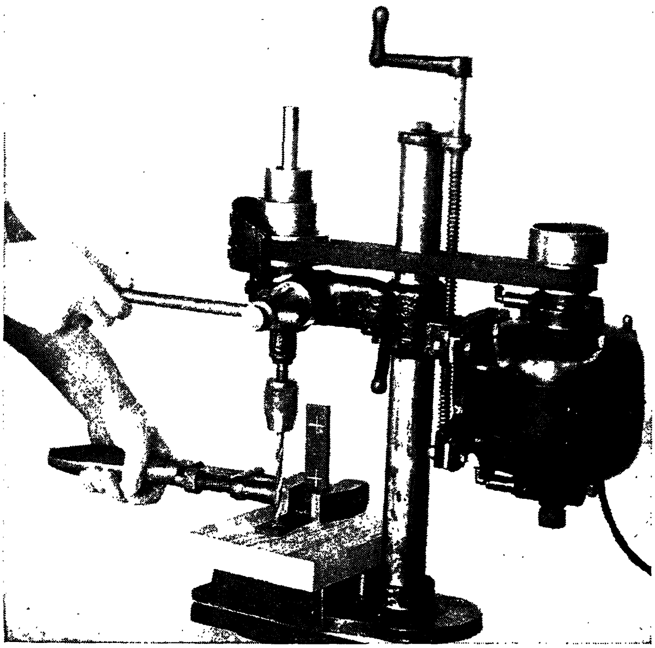

Fig. 79. Drilling with an electric bench drill. Do not hold stock in the hands while drilling

3. Select the Drill

First determine the exact size of the hole, and select the drill size accordingly. The size of the drill is stamped on the shank of drills as small as No. 52. Figure 76 shows the common types of drills used in the average shop, as well as the typical parts of a drill.

A square-shank drill is made to fit the chuck of the brace. It is called a "bit-stock drill," and should be selected when drilling with a brace. Such drills are made in varying sizes from 1/16 to 1¼ in. The smaller sizes can be had by 64ths up to ⅜ in.

For the hand drill, portable electric drill, and bench drill (with chuck), select straight-shank drills. These drills are obtained in sizes from 1/64 to ½ in. by 64ths of an inch. The common sizes for the average shop are 1/16 to ½ in. A metal stand for these drills is made to hold all the con-

Size	*Decimal*	*Size*	*Decimal*	*Size*	*Decimal*
80	0.0135	3/32″	0.0938	5	0.2055
79	0.0145	41	0.096	4	0.209
1/64″	0.0156	40	0.098	3	0.213
78	0.016	39	0.0995	7/32″	0.21875
77	0.018	38	0.1015	2	0.221
76	0.02	37	0.104	1	0.228
75	0.021	36	0.1065	A	0.234
74	0.0225	7/64″	0.1094	15/64″	0.2344
73	0.024	35	0.11	B	0.238
72	0.025	34	0.111	C	0.242
71	0.026	33	0.113	D	0.246
70	0.028	32	0.116	¼″	0.250
69	0.0292	31	0.12	E	0.250
68	0.031	⅛″	0.125	F	0.257
1/32″	0.0313	30	0.1285	G	0.261
67	0.032	29	0.136	17/64″	0.2656
66	0.033	9/64″	0.1406	H	0.266
65	0.035	28	0.1405	I	0.272
64	0.036	27	0.144	J	0.277
63	0.037	26	0.147	9/32″	0.2813
62	0.038	25	0.1495	K	0.281
61	0.039	24	0.152	L	0.290
60	0.04	23	0.154	M	0.295
59	0.041	5/32″	0.15625	19/64″	0.2969
58	0.042	22	0.157	N	0.302
57	0.043	21	0.159	5/16″	0.3125
56	0.0465	20	0.161	O	0.316
3/64″	0.0469	19	0.166	P	0.323
55	0.052	18	0.1695	21/64″	0.328
54	0.055	11/64″	0.1719	Q	0.332
53	0.0595	17	0.173	R	0.339
1/16″	0.0625	16	0.177	11/32″	0.34375
52	0.0635	15	0.18	S	0.348
51	0.067	14	0.182	T	0.358
50	0.07	13	0.185	23/64″	0.359
49	0.073	3/16″	0.1875	U	0.368
48	0.076	12	0.189	⅜″	0.375
5/64″	0.0781	11	0.191	V	0.377
47	0.0785	10	0.1935	W	0.386
46	0.081	9	0.196	25/64″	0.3906
45	0.082	8	0.199	X	0.397
44	0.086	7	0.201	Y	0.404
43	0.089	13/64″	0.203	13/32″	0.4063
42	0.0935	6	0.204	Z	0.413

Fig. 80. Continuous drill sizes from 80 to Z, including fractional sizes with decimal equivalents

venient sizes, and helps to keep the drills in order. This stand is also handy to check the sizes of drills by testing in a hole that fits the drill, the sizes of the holes being stamped on the stand. Straight-shank drills also are made in odd decimal sizes ranging from No. 80 to No. 1, by numbers; also from A to Z by letters. No. 80 is the smallest and Z the largest

in this system of gauging. Figure 80 is a table of continuous drill sizes from 80 to Z with their decimal equivalents.

Select taper-shank drills for drilling holes larger than ½ in. with bench drills equipped with a taper-shank socket. If no machine drill is available, use a large bit-stock drill and the brace, and drill by hand.

4. Sharpen a Drill (if necessary)

Twist drills are best sharpened with a point-grinding attachment on a grinding wheel. The proper angle between the cutting edge and the axis

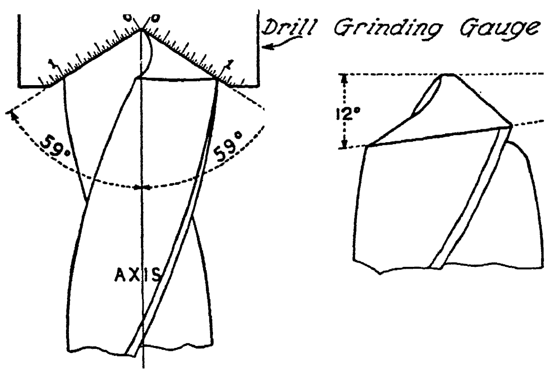

Fig. 81. Detail for correct grinding of twist drills

is 59 deg. The two cutting edges should be straight, of equal lengths, and have a lip clearance of 12 to 15 deg. If grinding must be done by hand, use a drill-grinding gauge, as shown in Figure 81, for frequent testing.

5. Arrange to Hold the Metal Bar Securely

For hand drilling, clamp the bar, if possible, in a vise.

For bench drilling, numerous methods are used to hold the metal. *Do not attempt to hold small pieces in the hands while drilling. Injury may result from such practice.* Small pieces may be held with a monkey wrench, pliers, or some other clamping device (see Fig. 79). A drill vise is a special tool used for this purpose. A portable drill vise that rests on the base of the drill is shown in Figure 82. A "V" block useful for holding round stock is shown in the same figure.

A V block is useful for holding a round bar while drilling.

6. Drill the Hole

When using straight-shank drills, clamp the drill securely in the chuck. This is especially important when using power drills, as it prevents the drill from slipping in the chuck and cutting the shank.

Start the drilling carefully to be sure it is at the proper place. Use lard oil or a cutting solution on the drill for steel, but a dry drill for cast iron or brass. Hold the hand tools steady while drilling. Change of direction or wabbling may break the drill. Apply enough pressure to make the drill cut rather than slip. A drill that does not cut properly is easily burned. Inspect the cutting edge and, if worn or chipped, resharpen. As the hole starts to come through reduce the pressure until the hole is entirely through. This will eliminate a tendency of the drill to catch in the piece and break, or catch in the piece and swing it violently around. Bad cuts to the hands may result from the latter.

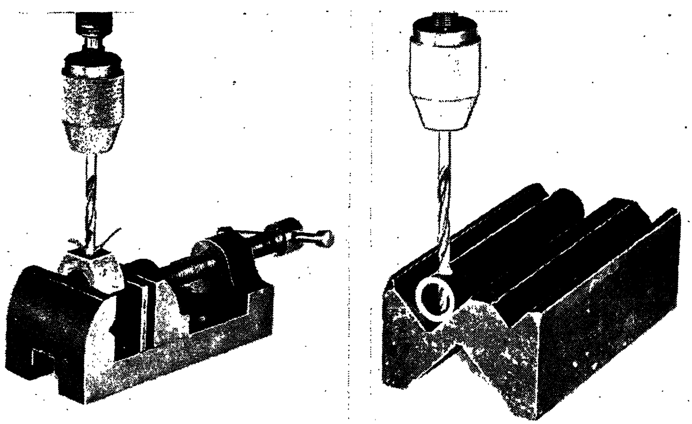

Fig. 82. Method of using drill vise and "V" block for holding stock in place while drilling

A general rule for drill speeds is to run small drills fast and large drills slow. On some bench drills the speeds are indicated on the machine. Note the suggested speeds on page 55.

7. Pilot Holes

When drilling large holes, it is often advisable to drill a small hole first. This may save time and be of assistance in drilling the hole in the proper place. Select a small drill equal, at least, to the diameter of the dead center of the large drill. Center punch and drill the small hole, then follow with the large drill. This method is especially useful for hand drilling. When drilling large holes by hand, exert pressure rather than speed.

8. Countersink a Hole

Holes are countersunk to receive the tapered heads of screws, bolts, or rivets, so that the surface may be entirely flat. To countersink by hand, use the brace and a rose countersink bit as shown in Figure 83. Back up

thin pieces with a block of wood to keep the metal from bending. The proper size of the countersunk hole can be tested by inserting the head of the screw or rivet upside down.

Countersinks are made with straight shanks so they can be used in drilling machines like straight-shank drills.

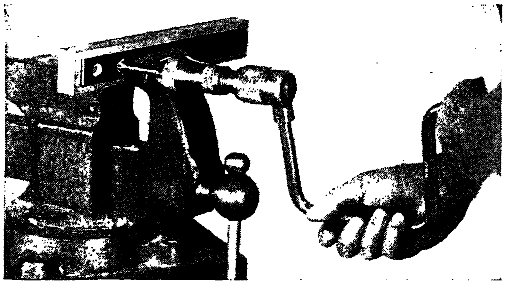

Fig. 83. Using a brace with a countersink bit

STUDY QUESTIONS:

1. Name the common parts of every twist drill.
2. Where is the size of a twist drill stamped?
3. What is the use of center punching for drilling?
4. What type twist drill is used in the brace? In the hand drill?
5. What is the advantage of electric drills?
6. What is an outstanding advantage of the bench drill?
7. When would you use the taper-shank drill?
8. Give some specifications for sharpening a twist drill.
9. Give some cautions to be observed during drilling operations.
10. What is the use of the V block in drilling?
11. Give a general rule for drill speeds of small and large drills.
12. What is the method in countersinking a hole?

Unit 13

TO RIVET SHEET METAL

Riveting is a common method of fastening metal where a permanent connection is needed. It would not be advisable to use rivets where a joint might have to be separated at intervals.

Rivets are made of soft metal, such as iron, brass, copper, and aluminum, so that they can be readily headed by hand or machinery. The common rivet types used in sheet metal are shown in Figure 85.

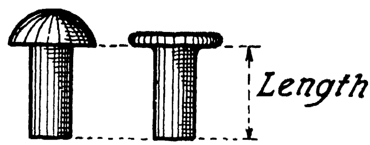

Fig. 85. Round- and flat-headed rivets

Tinner's rivets are made of either black or tinned iron, and are commonly used in riveting sheet metal (see Fig. 86). They always are of the flat-headed type and are generally sold in boxes of a thousand each. The size is indicated by the weight of a thousand rivets. A thousand of "one-pound" size rivets weigh one pound; a thousand of "two-pound" size rivets weigh two pounds, etc. Therefore, the more the weight, the larger the rivets. Tinner's rivets are only made in one length for each size or weight.

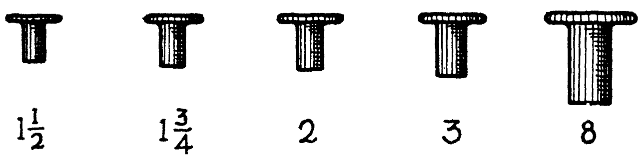

Fig. 86. Tinner's rivets (full size). Numbers indicate weight per thousand

Round-headed rivets in different diameters and lengths can be had in iron, copper, brass, and aluminum. They are used in a manner similar to the tinner's rivets, and can be purchased in 1-lb. packages. The round-headed rivet, when used in thin metal, adds to the appearance of the project.

Three methods for setting rivets are described in the following: Method A is used where accuracy is desired. Method B is generally used by the

sheet-metal worker. Method C describes the setting of round-headed rivets where appearance is important. Select the one most suitable.

Tools: Punch or drilling tool; rivet set; riveting hammer; anvil.

Materials: Sheet metal to be riveted; rivets.

METHOD A: To Set Tinner's Rivets

1. Locate the Rivet Holes

Rivets are usually located in the center of the width of a seam. With laying-out tools and a center punch, locate the exact positions of the rivet holes. Extreme accuracy is essential so that the holes will be in line.

2. Punch or Drill the Holes

Make holes slightly larger than the diameter of the rivet. For a lap seam, check to see if the holes are in alignment.

3. Set a Rivet

Stand a rivet (head down) on some solid-metal surface. Lower the seam over it so that the rivet sticks up through the hole. Place the hole of the rivet set over the rivet, and strike the set several times with a hammer. Remove the rivet set. The head of the rivet is now set and the laps are drawn together.

4. Head a Rivet

First: Strike the rivet several times with a riveting hammer to upset it (see Fig. 87). These blows will spread the rivet stem and cause it to fill the hole. Only a few blows are necessary to upset the rivet and hold

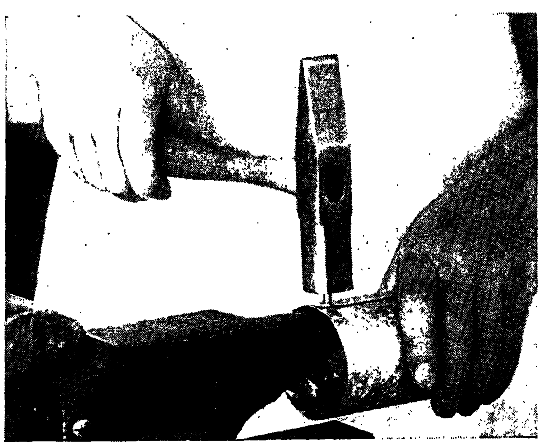

Fig. 87. Striking a rivet to upset it and flattening it for a head

the joint in place. A few additional blows will partly form the rivet head. Too much hammering will stretch the seam and cause it to buckle.

Second: Round the flattened rivet head by placing the cup-shaped depression of the rivet set over it, and again strike with a hammer. Again, use only several hammer blows for heading. The set is used for rounding the head in a manner to that shown in Figure 88.

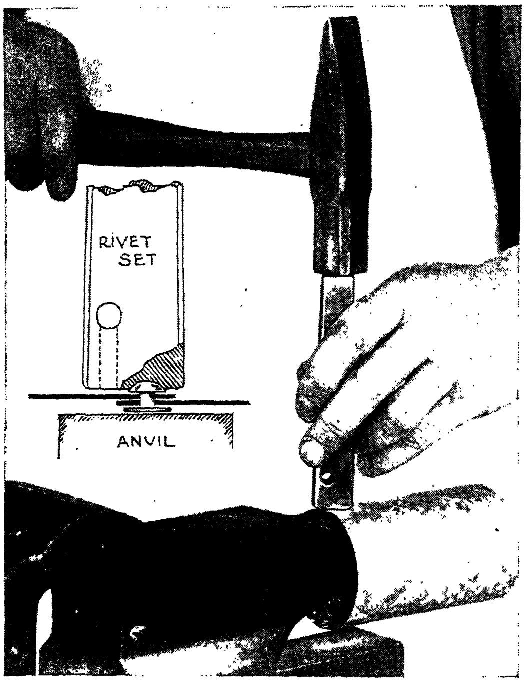

Fig. 88. Shaping a head with a rivet set

5. Set and Head Other Rivets in a Seam

If a seam requires a number of rivets, set the rivets loosely at the ends. Then start riveting at the center and work toward the ends. If the holes do not line up exactly, drive in a scratch awl or drift pin to make proper alignment. Then insert the rivet and head it.

METHOD B: To Set Tinner's Rivets without First Making Holes

Stand a rivet head down, and place the seam over the rivet. Tap with a hammer directly on the seam above the rivet. A round "spot" locates the exact position of the rivet (see Fig. 89). Place the hole of the rivet set over this spot and strike the set with the hammer until the rivet is "drawn up" through the metal (see Fig. 90). Then head as before.

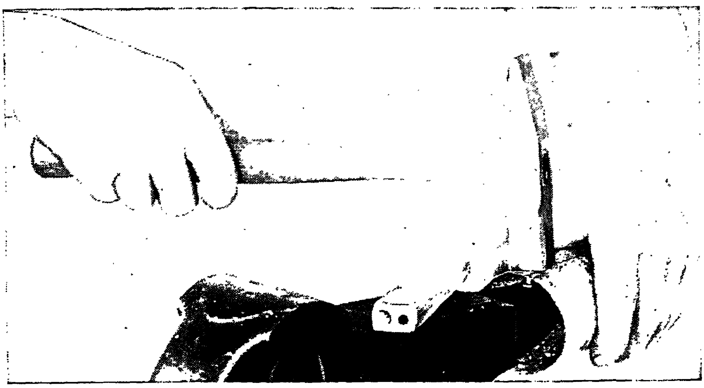

Fig. 89. Spotting a rivet

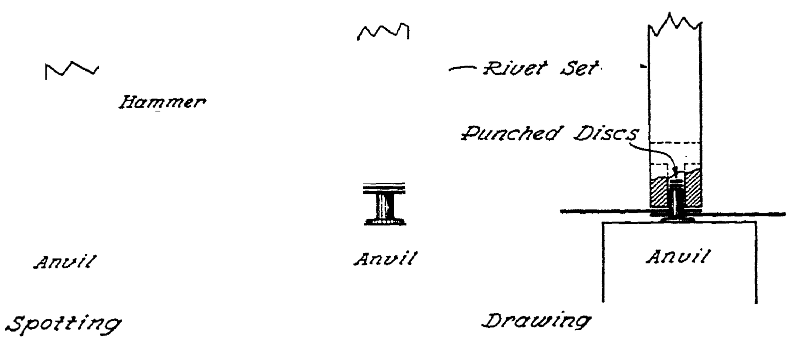

Fig. 90. Method of spotting and drawing a rivet

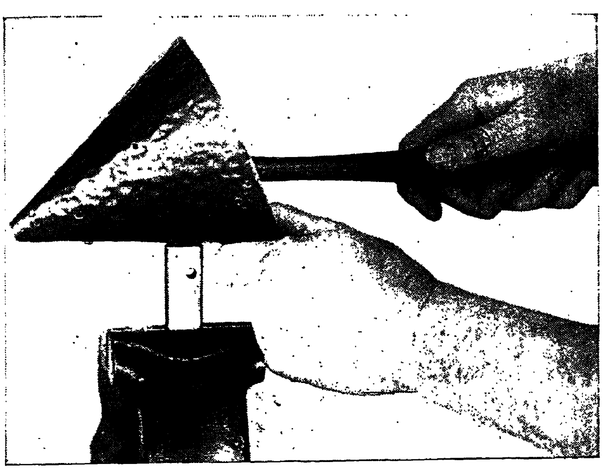

Fig. 91. Backing up round-headed rivets
with a rivet header

METHOD C: To Set Round-Headed Rivets

Round-headed rivets are often desired for a more finished appearance in ornamental work. If possible, place the original round head to the exposed side of the seam; then use the cup-shaped depression of a rivet set to back up the rivet while the heading is done from the opposite side (see Fig. 91). This method prevents the flattening of the round rivet head.

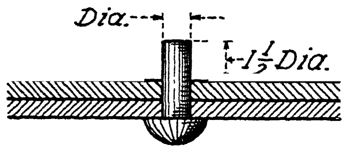

Fig. 92. Length of rivet stem necessary to make a full round head

Since round-headed rivets are made in various lengths, they may be too long for proper heading. After the rivet is inserted in the hole, any excess can be readily cut off with the nippers. Figure 92 shows the proper amount of stem necessary to form a full round head. If only a flat head is desired, less of the stem is allowed to project.

STUDY QUESTIONS:

1. Why are rivets made of a soft metal?
2. Of what metals are rivets made?
3. What two types of rivets are generally used in sheet metal?
4. How is the size of tinner's rivets indicated?
5. When are round-headed rivets used?
6. What is meant by "spotting" a rivet? "drawing" a rivet?
7. How are rivets headed?
8. How can you protect the head of a round-head rivet while setting and heading?
9. How much of a rivet stem is necessary to make a full round head?

Unit 14

TO FASTEN WITH SELF-TAPPING SCREWS

Metalworkers now use a screw that forms its own thread in the metal as it is turned in. This type of screw is called a "self-tapping" screw. Its thread structure is similar to that of a wood screw, but the steel is hard enough to cut glass. This type of screw is fastened in the same manner as a wood screw. A hole is made in the metal, and the screw is turned in with a screw driver. If necessary, the screw can be removed and replaced in the same hole without reducing the strength of the fastening. Figure 95 shows two types of these screws. Type A screws are for light gauges

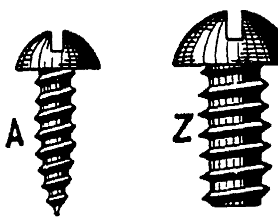

Fig. 95. Two types of self-tapping screws

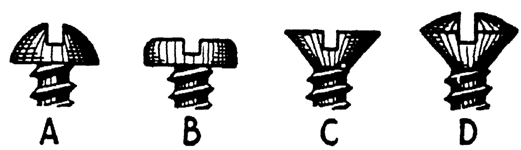

Fig. 96. Common heads obtainable in both types of self-tapping screws. A, round head; B, binding head; C, countersunk flat head; D, countersunk oval head

of sheet metal, and type Z screws are for use in heavy metal. This screw also can be used for joining and making fastenings to aluminum and die castings, Bakelite, Durez, slate, ebony, asbestos, etc. Figure 96 shows the heads available for both types of screws. The lengths and diameters of these screws also are similar to the wood screw.

The self-tapping, sheet-metal screw has many advantages, and is being used extensively in the trade as a quicker, easier, and cheaper means of making strong fastenings.

Tools: Drilling or punching tools; screw driver.

Materials: Metal to be fastened; self-tapping screws.

METHOD:

1. Select the Screw

For light-gauge metal select the type A screw shown in Figure 95. This screw is recommended for joining sheet metal and making fastenings to sheet metal not exceeding 18 gauge (.050 in.).

For heavy-gauge metal select the type Z screw shown in Figure 95. This screw is recommended for joining and making fastenings to sheet metal up to 6 gauge (.203 in.). It is also recommended for assembling articles made of aluminum, Bakelite, Durez, fiber, ebony, asbestos, and slate.

Diameter of Screw	Thickness of Metal		Pierced Hole	Drilled or Clean-Punched Hole	
	Number of Gauge (U. S. Std.)	Thickness in Dec. Pts. of an Inch	Diameter of Hole Required	Diameter of Hole Required	Drill Size
No. 4	No. 28	.015″	.086″	.086″	No. 44
	No. 26	.018″	.086″	.086″	No. 44
	No. 24	.025″	.093″	.093″	No. 42
	No. 22	.031″	.098″	.093″	No. 42
	No. 20	.037″	.100″	.098″	No. 40
No. 6	No. 28	.015″	.111″	.099″	No. 39
	No. 26	.018″	.111″	.099″	No. 39
	No. 24	.025″	.111″	.099″	No. 39
	No. 22	.031″	.111″	.101″	No. 38
	No. 20	.037″	.111″	.106″	No. 36
No. 7	No. 28	.015″	.121″	.104″	No. 37
	No. 26	.018″	.121″	.104″	No. 37
	No. 24	.025″	.121″	.110″	No. 35
	No. 22	.031″	.121″	.113″	No. 33
	No. 20	.037″	.121″	.120″	No. 31
	No. 18	.050″	....	.128″	No. 30
No. 8	No. 26	.018″	.137″	.113″	No. 33
	No. 24	.025″	.137″	.113″	No. 33
	No. 22	.031″	.137″	.113″	No. 33
	No. 20	.037″	.137″	.116″	No. 32
	No. 18	.050″	....	.120″	No. 31
No. 10	No. 26	.018″	.158″	128″	No. 30
	No. 24	.025″	.158″	.128″	No. 30
	No. 22	.031″	.158″	.128″	No. 30
	No. 20	.037″	.158″	.136″	No. 29
	No. 18	.050″	.158″	.149″	No. 25
No. 12	No. 24	.025″	....	.147″	No. 26
	No. 22	.031″	.185″	.149″	No. 25
	No. 20	.037″	.185″	.152″	No. 24
	No. 18	.050″	.185″	.157″	No. 22
No. 14	No. 24	.025″	....	.180″	No. 15
	No. 22	.031″	.212″	.189″	No. 12
	No. 20	.037″	.212″	.191″	No. 11
	No. 18	.050″	.212″	.196″	No. 9

Fig. 97. Sizes of holes recommended for using type A screws

2. Make the Holes

See Figures 97 and 98 for sizes of holes for each different size and type of screw. The size of the hole depends upon the kind of material and the thickness. It is very essential that the proper size of hole be made. If the hole is too large, the screw will not hold. If made too small, the head of the screw may be twisted off when the drive is made.

When joining two thicknesses of light-gauge sheet metal, the holes may be drilled or clean-punched the same size in both sheets as shown in A, Figure 99; or a clearance hole can be provided in the upper sheet. If conditions permit, both sheets may be pierced together so that the burrs are nested, as shown in B. This form is preferable because it results in a stronger fastening. When fastening a part in which clearance holes are provided and the sheet metal is of light gauge, it is desirable to make

Diameter of Screw	*In Sheet Steel* — Thickness of Metal		Pierced Hole	Drilled or Clean Punched Hole		*In Aluminum, Die Castings, Etc.*		*In Bakelite, Durex, Calalith, Etc.*		*In Slate, Ebony Asbestos, Etc.*	
	No of Gauge (U S. Standard)	Thickness in Dec Parts of an Inch	Diam. Hole Required	Diam. Hole Required	Drill Size	Diam. Hole Required	Drill Size	Diam. Hole Required	Drill Size	Diam. Hole Required	Drill Size
No. 2	28	.015"	...	.063"	No. 52	.078"	No. 47	.078"	No. 47	.076"	No. 48
	26	.018"	...	.063"	No. 52						
	24	.025"	...	.067"	No. 51						
	22	.031"	...	.070"	No. 50						
	20	.037"	...	.073"	No. 49						
	18	.050"	...	.073"	No. 49						
	16	.062"	...	.076"	No. 48						
No. 4	28	.015"	.086"	.086"	No. 44	.104"	No. 37	.099"	No. 39	.101"	No. 38
	26	.018"	.086"	.086"	No. 44						
	24	.025"	.093"	.089"	No. 43						
	22	.031"	.098"	.093"	No. 42						
	20	.037"	.100"	.093"	No. 42						
	18	.050"	...	.096"	No. 41						
	16	.062"	...	.099"	No. 39						
	14	.078"	...	.101"	No. 38						
No. 6	28	.015"	.106"	.104"	No. 37	.128"	No. 30	.128"	No. 30	.120"	No. 31
	26	.018"	.106"	.104"	No. 37						
	24	.025"	.106"	.106"	No. 36						
	22	.031"	.110"	.106"	No. 36						
	20	.037"	.110"	.110"	No. 35						
	18	.050"	...	.111"	No. 34						
	16	.062"	...	.116"	No. 32						
	14	.078"	...	.120"	No. 31						
	12	.109"	...	.128"	No. 30						
No. 7	26	.018"	.121"	.116"	No. 32	.144"	No. 27	.136"	No. 29	.136"	No. 29
	24	.025"	.121"	.116"	No. 32						
	22	.031"	.121"	.116"	No. 32						
	20	.037"	.121"	.116"	No. 32						
	18	.050"	...	.120"	No. 31						
	16	.062"	...	.128"	No. 30						
	14	.078"	...	.136"	No. 29						
	12	.109"	...	.140"	No. 28						
No. 8	26	.018"	.131"	...		.152"	No. 24	.149"	No. 25	.147"	No. 26
	24	.025"	.131"	.116"	No. 32						
	22	.031"	.131"	.116"	No. 32						
	20	.037"	.136"	.116"	No. 32						
	18	.050"	.140"	.128"	No. 30						
	16	.062"	...	.136"	No. 29						
	14	.078"	...	.140"	No. 28						
	12	.109"	...	.149"	No. 25						
	1,8"	.125"	...	.149"	No. 25						
	10	.140"		.152"	No. 24						
No. 10	26	.018"	.144"	.144"	No. 27	.177"	No. 16	.177"	No. 16	.166"	No. 19
	24	.025"	.144"	.144"	No. 27						
	22	.031"	.144"	.144"	No. 27						
	20	.037"	.147"	.144"	No. 27						
	18	.050"	.155"	.144"	No. 27						
	16	.062"	...	.152"	No. 24						
	14	.078"	...	.157"	No. 22						
	12	.109"	...	.161"	No. 20						
	1/8"	.125"	...	.169"	No. 18						
	10	.140"	...	.169"	No. 18						
	8	.171"	...	.173"	No. 17						
No. 12	24	.025"	.185"	.166"	No. 19	.199"	No. 8	.199"	No. 8	.196"	No. 9
	22	.031"	.185"	.166"	No. 19						
	20	.037"	.185"	.166"	No. 19						
	18	.050"	.185"	.169"	No. 18						
	16	.062"	...	.177"	No. 16						
	14	.078"	...	.182"	No. 14						
	12	.109"	...	.185"	No. 13						
	1/8"	.125"	...	.196"	No. 9						
	10	.140"	...	.196"	No. 9						
	8	.171"	...	.201"	No. 7						
No. 14	22	.031"	.209"	.185"	No. 13	.234"	15/64"	.234"	15/64"	.228"	No. 1
	20	.037"	.209"	.185"	No. 13						
	18	.050"	.209"	.191"	No. 11						
	16	.062"	...	.199"	No. 8						
	14	.078"	...	.204"	No. 6						
	12	.109"	...	.209"	No. 4						
	1/8"	.125"	...	.228"	No. 1						
	10	.140"	...	.228"	No. 1						
	8	.171"	...	.234"	15/64"						
	3/16"	.187"	...	.234"	15/64"						
	6	.203"	...	.234"	15/64"						

Note: To obtain satisfactory results the holes must be neither too large nor too small. In most cases the hole sizes shown in the table will be found suitable but if the material in which the Screws are to be used happens to be very hard it might be necessary to use a size larger drill and in very soft material a size smaller drill should be used.

Fig. 98. Size of holes recommended for using type Z self-tapping screws in various materials

the holes in the sheet metal with a burr as shown in C, thus presenting a greater surface for the screw to engage.

The portable electric drill is convenient for drilling holes in hollow, sheet-metal objects in which a fastening must be made. In thin metal only a pilot hole is usually drilled in both pieces, or if practical, both pieces of metal can be pierced with a punch (see A and B, Fig. 99). In

Fig. 99. Making holes in thin metal

heavy metal, a shank hole (clearance hole) is usually made in the first piece and a pilot hole in the one to which the fastening is made (see Figs. 99 and 100).

Fig. 100. Driving a type Z screw into place

3. Drive the Screw

Both the A and the Z types of screws are driven with a screw driver. Use a well-fitted screw driver, and turn the screw into place. Draw the joint tight but not too tight. By using all the strength you possess, it

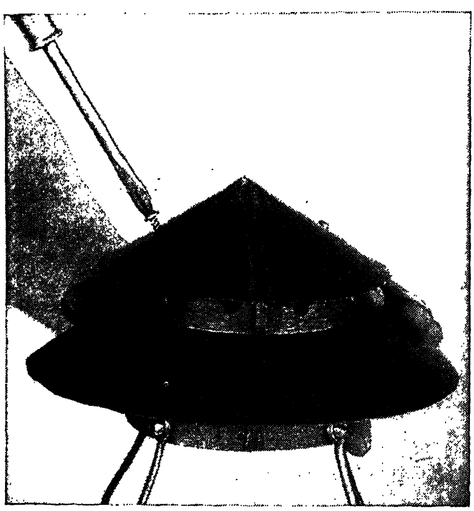

Fig. 101. Fastening top to lantern
with a self-tapping screw

might be possible to turn the head from a screw or strip the threads in the hole. Try to overcome this difficulty by using the proper size hole, and stop the driving when the screw is tight.

STUDY QUESTIONS:

1. What is a self-tapping screw?
2. In what way does this screw differ from the wood screw?
3. State the uses of the two types of these screws.
4. Name several advantages of the self-tapping screw.
5. Why is it essential to have the hole very accurate?
6. Name several methods of making holes for self-tapping screws (see Fig. 99).
7. What is likely to happen if you use too much force in turning the screw into place?

Unit 15

TO RAISE METAL

When a metalworker wishes to construct a project having a depressed or a raised surface, from a flat piece, he resorts to the process of raising the metal. Raising is a method of stretching the metal by hammering it in a depression or over an arris to produce the desired shape. The resulting hammer marks often add to the beauty of an object formed by raising.

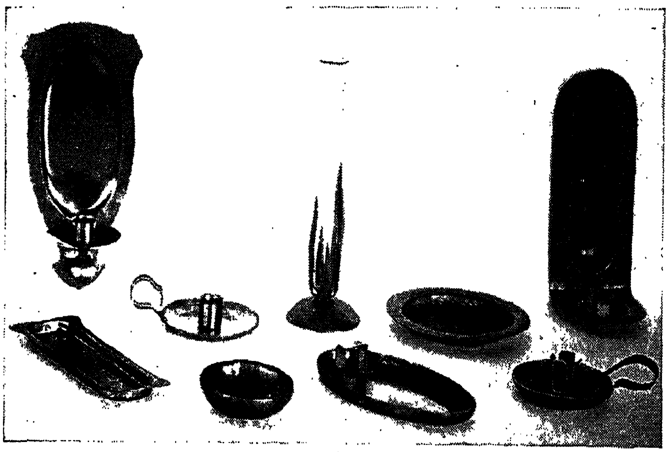

Fig. 104. All of these projects were shaped by raising

The soft and more ductile metals are used by the craftsman for raising purposes. Ductility means the ability to be drawn out or stretched. Silver, pewter, copper, brass, and aluminum lend themselves well for raising. Sheet iron and tin plate, while not so soft and ductile, may also be shaped by this process. Figure 104 shows several projects that were raised with very little equipment.

Tools: Raising hammer; form or backblock.

Material: Metal to be raised.

METHOD:

1. Cut Metal to Desired Size

The size and shape of the project will determine the size to cut. It is

sometimes necessary to cut the metal ¼ to ½ in. larger all around, and finally recut after it has been raised.

2. Outline the Portion to be Raised

Guide lines for any raised portions are conveniently added when the metal is in the flat. Lay out any circles, ellipses, or special curves at this time, with either pencil or chalk that will not scratch the metal. If the entire surface is to be raised, marking may be unnecessary.

3. Select or Make the Block

The end of a close-grained hardwood block is well suited for raising metal (see Fig. 105). Sometimes a section of a log is set on end for this

Fig. 105. The end grain of a wooden block is suitable for raising

purpose. A block of lead with hollows or depressions also is used. Depressions of different depths and diameters can be made to suit the particular needs. Shallow depressions generally are used by the craftsman. These depressions can be made by striking the block with a raising hammer. A stout canvas bag filled with sand sometimes is used for backing in place of a solid block. For making small, flanged trays, forms of the exact shape and depth are convenient. Wooden forms, as shown in Figure 106, are readily made by turning a maple block on a wood lathe. If a number of raised pieces are to be made the same shape, a more permanent form may be made from metal. Metal forms of standard shapes are furnished by firms specializing in metalworking tools.

4. Select the Raising Hammer

Select a raising hammer whose curvature corresponds most nearly to

the curve desired. Raising hammers are made with faces of different shapes and sizes. Figure 105 shows a typical raising hammer in use.

A ball-peen hammer may be used for a great variety of raising work if a raising hammer is not available.

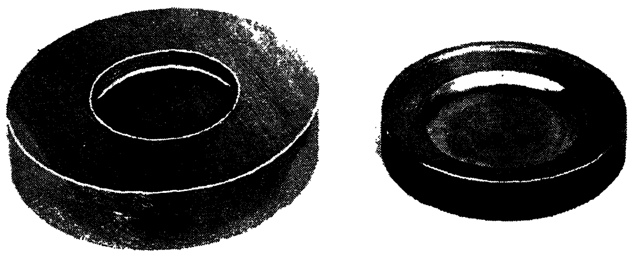

Fig. 106. Wooden and metal forms are convenient for raising plates, trays, etc.

5. Anneal the Metal (if necessary)

"Anneal" means to soften metal. To anneal copper or silver, heat to a dull red and plunge it into cold water. If 1 part of nitric acid is added to 4 parts of water the metal is not only annealed but left clean.

Metal stretched with raising becomes hard, and cracks easily when struck with a hammer. To avoid this cracking, the worker anneals the metal often. Metal to be raised is best worked if it is soft and ductile. Copper, brass, and iron must be softened if they are raised to any great extent. Raise the entire surface a small amount after each annealing.

Dipping into the water and acid is called "pickling."

Heat aluminum to a dull pink and anneal in a subdued light. Aluminum need not be pickled.

Iron must be heated and allowed to cool slowly to make it soft.

It is not necessary to anneal pewter or britannia metal if the raising is not forced.

6. Raise the Metal

For bowls, begin at the center or inner edge of the portion to be raised. Hold the metal over the depression and with a raising hammer, strike it with light blows. Turn the metal slowly and continue to strike it, hammering in concentric circles. Gradually work toward the outer edge of the bowl. The blows should be close together, evenly placed, and not too heavy.

For raising a plate or tray with a rim, the blows are confined more to

the outer edge of the depression or bulge. Strike gently until the depression is formed. If the blows are too heavy the rim will buckle. Do not hammer the center of a bulge that is to remain flat, but confine the hammering to the outer edge. Stop the hammering before the bulge becomes larger than the depression in the form (see Fig. 107).

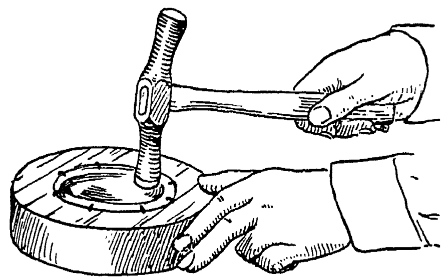

Fig. 107. Using a wooden form to raise a plate

Raising also is accomplished without the use of a block with depressions. Trays, plates, etc., with a rim can be successfully fashioned on the flat surface of a wood or metal block. Figure 108 shows the raising of a

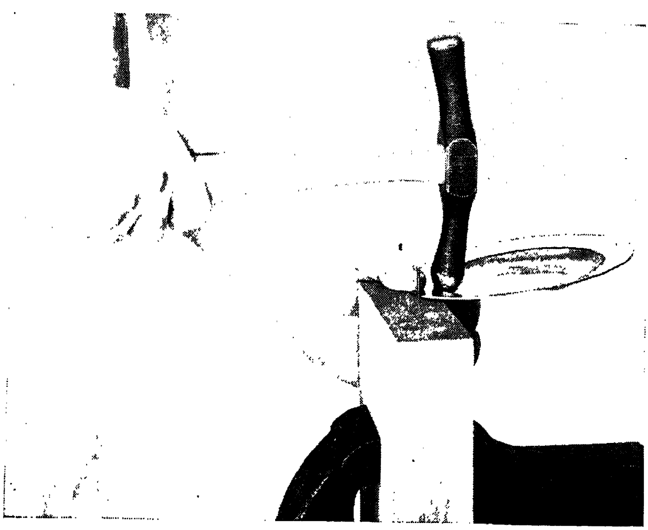

Fig. 108. Raising metal on the arris (edge) of a wooden block

pewter plate with a raising hammer over the arris (edge) of a wooden block. The two nails serve as guides to give a uniform rim around the plate.

7. Planish all Surfaces (if necessary)

Sometimes the metalworker finishes the raised surface by placing it on a round stake and, with a planishing hammer, pounds out the irregularities from the opposite side. A planishing hammer, a typical example of which is shown in Figure 109, is one with flat or rounded faces, used to give a finished surface to the project after it has been shaped.

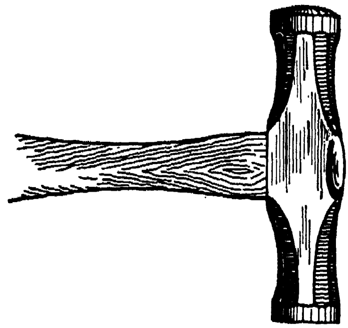

Fig. 109. A typical planishing hammer

If the inner surface is to be exposed, the project may be placed on a smooth, metal surface and planished from the inside. Planishing hardens the metal and gives it a finished appearance.

8. Apply Final Finish Where Needed

With 2/0 or finer steel wool, brighten all surfaces. For producing a very high polish or luster, use a silver polish or rouge. Common whiting, as a polish, is often used for this purpose. Tin plate is polished by using whiting only. After polishing, wash in ammonia water and dry.

To retain this polish or finish, it is best to coat the surface with transparent lacquer or wax. See Unit 21 for this and other finishes.

STUDY QUESTIONS:

1. How is raising accomplished?
2. What metals are used for raising? Why?
3. What is used for a backblock in raising?
4. Describe the raising hammer.
5. Why are metals annealed that are being raised?
6. What is "pickling"?
7. How do you anneal copper and brass? Iron?
8. What kind of blows are used for raising?
9. What may happen to a tray if the pounding is too heavy?
10. How can one raise metal without the use of a mold?
11. What is planishing and how is it accomplished?

Unit 16

TO SAW METAL

A hack saw is used for sawing metals. It is a U-shaped frame arranged to hold removable saw blades. Two types of saw frames are shown in Figures 111 and 112. The adjustable type of frame will take blades 8 to 12 in. in length. A wing nut at the end of the frame allows the saw blades to be removed or tightened to the proper tension.

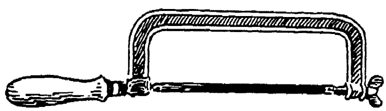

Fig. 111. Nonadjustable hack-saw frame with straight wood handle

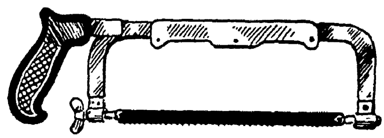

Fig. 112. Adjustable hack-saw frame with "pistol-grip" handle

Hand hack-saw blades are made in 8-, 10-, or 12-in. lengths, and in 7/16-, 1/2-, or 9/16-in. widths. These different sizes are made with coarse and fine teeth. The number of teeth to the inch available are 14, 18, 24, and 32.

Hack-saw blades are made similar to wood saws, but they are very much harder. They are made of "all-hard" steel or "flexible-back hard-teeth" steel. Hack-saw blades are not resharpened since they are very hard and brittle. Because of their hardness they are likely to break if not handled properly. The flexible type will not break as easily, however, as the "all-hard" steel.

Tools: Hack saw; vise.

Material: Metal bar to be cut.

METHOD:

1. Lay Off for the Cut

With a rule and a laying-out tool, mark a line for the cut.

2. Clamp the Bar

Securely clamp the bar for successful sawing. A vise generally is used for this purpose. If possible, arrange for sawing the material as shown in Figures 113 and 114. Fasten so the line of cut is quite close to the jaws. This will help to eliminate vibration which is likely to occur in metal sawing. For long cuts, reclamp the piece frequently so as to be

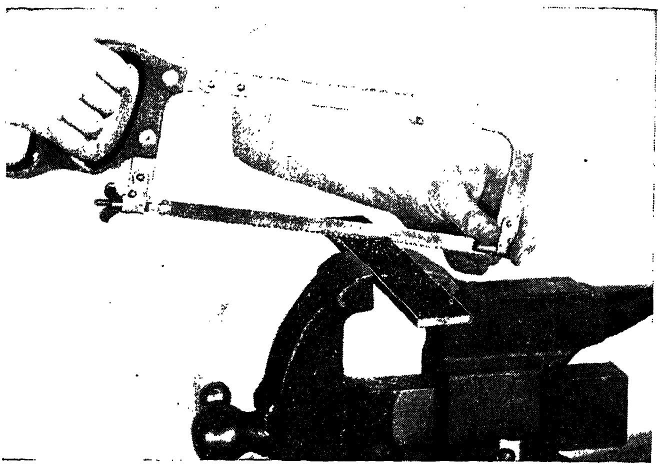

Fig. 113. Sawing a metal bar

sawing near the jaw as shown in Figure 114. When sawing flats, clamp the piece, if possible, so that the cut is made along the flat side rather than through the narrow portion (see Fig. 113). This tends to eliminate vibration and also preserves the teeth of the saw blade. Sawing flat pieces of metal through the narrow portion will strip teeth from the saw.

3. Select Saw with Proper Blade and Adjust

Several types of hack-saw frames are available. A saw with a hand grip, as shown in Figure 112, is very easily handled by the beginner. If

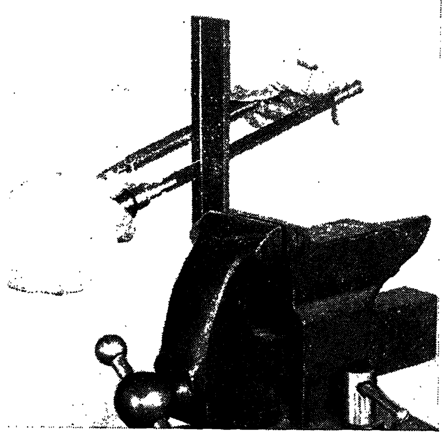

Fig. 114. The blade is clamped at right angles to the frame for making long cuts as shown

different blades are available, select as follows according to the piece to be cut.

A blade ½ in. wide and 10 in. long, with 18 teeth to the inch, is good for average work with iron. For sheet metals, thin tubes, and pipes, a blade with 32 teeth will give better results.

To insert a blade, loosen the wing nut at the end of the saw. Then insert the blade with the teeth pointing forward (away from the handle) so that the cut is made on the forward stroke. Tighten the wing nut so the saw blade is tight. For sawing average material the blade should be clamped as in Figure 113. For a long cut greater than the depth of the saw frame, set it at right angles to the frame as shown in Figure 114.

4. Saw the Cut

Grasp the saw as shown in Figures 113 and 114, and operate with a steady, uniform motion. Start slowly at first, and increase the strokes to about 35 per minute. Apply pressure on the forward stroke, and release the pressure on the return or backward stroke. On each stroke use the entire length of the blade. Short strokes will cause the blade to wear unevenly and make it bind at the ends.

When sawing, always move the blade in the same straight line. Saw blades are often broken because of failure to observe this rule. Moving out of line may kink the blade and cause it to break.

Sometimes a kerf (saw cut) wider than the thickness of a single blade is desired. This can be made by using two or more blades side by side in the saw frame.

For sawing very thin metal, two blades set side by side also may be used to advantage, but the teeth should be set so that they point in opposite directions.

STUDY QUESTIONS:

1. What is the name of the saw used for sawing metal?
2. What is meant by an adjustable saw frame?
3. How are saw blades removed and tightened?
4. State the sizes and number of teeth of hand hack-saw blades that are furnished.
5. How do hack-saw blades differ from wood saws?
6. Is it customary to resharpen hack-saw blades?
7. State specifications for a hack-saw blade for average work.
8. What kind of saw blades are recommended for work on thin stock?
9. How should a hack-saw blade be inserted in the frame for making very deep cuts?
10. State some rules for operating the hack saw.
11. When is it desirable to use more than one blade in the saw frame?

Unit 17

TO CUT OR SHEAR HEAVY METAL

One method of cutting heavy metal is with a cold chisel. A common, flat, cold chisel is shown in Figure 117. Cold chisels are forged from tool steel. The cutting edge must be properly hardened, and while it may be ground straight across, as shown, it is better for average work to have it slightly rounded. The best bevel for the cutting edge of a chisel for ordinary work is about 65 deg. The head of the chisel should be given as much attention as the cutting edge. It must be properly hardened so that it will not chip or burr. Figure 117 shows the proper shape for the head end of the chisel.

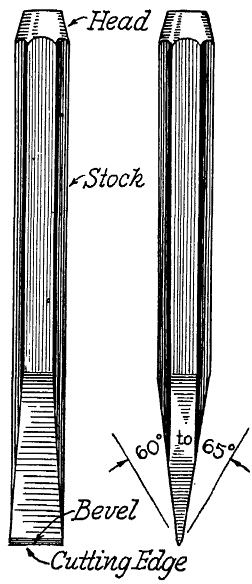

Fig. 117. Two views of a common cold chisel

When cutting, the cold chisel is used in connection with a metal backplate or a metal vise. The chisel is struck with a hammer so that it cuts its way through the metal. Cutting with a chisel is slow work but it is sometimes the only method available. Method A describes the common methods of cutting with a cold chisel.

Shearing is a process of cutting with an instrument having two blades. The shearing of tin was described in Unit 3. Heavy metal is sheared in a similar manner, but it requires heavier blades or jaws. Several hand methods for shearing are described in Methods B and C. Here the monkey wrench and the chisel are used in connection with a metal vise to make a shearing cut.

A bench-lever shear is shown in Figure 73. Method D describes the use of the bench-lever shear or the heavy floor shear. When such machines are available, they afford means for quick and efficient shearing of heavy metal.

Combination pliers, end nippers, and bolt clippers are special hand tools that are useful for cutting off wire and bolts (see Method E).

When cutting or shearing with tools, take care to cut only soft materials. Hardened steel such as drill rod, hack-saw blades, watch springs, etc., should not be cut with tools. This steel will damage the edges of tools and flying pieces cut from the steel might cause injury to the operator.

Material: Metal to be sheared or cut.

METHOD A: To Cut with Cold Chisel and Backplate

Tools: Cold chisel; anvil; or solid metal plate.

Mark for the cut with a scriber or a piece of chalk. Lay the metal bar on an anvil or a solid metal plate. Grasp the stock of the chisel with one hand as shown in Figure 118. Hold the chisel perpendicular to the

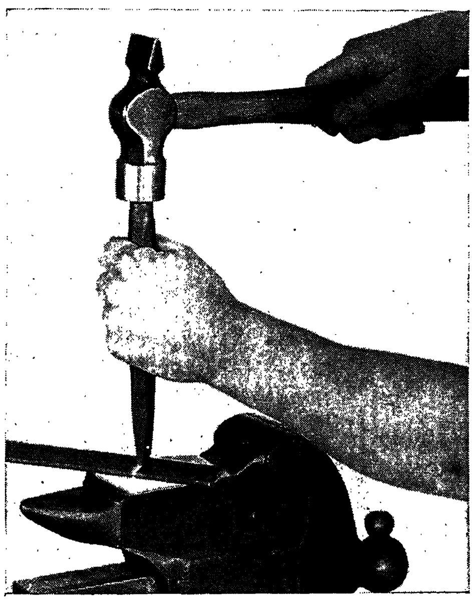

Fig. 118. Cutting a metal bar with a cold chisel. Note the bar is scored from both sides

work, and strike it with a hammer. Strike light blows at first, lifting the chisel to see if it is cutting at the proper place. Hard blows may then be used when an initial groove has been properly started. When it is necessary to cut all the way through from one side, care should be taken not to cut into the backplate. A common method is to cut the metal partly through from one or both sides and then break it by bend-

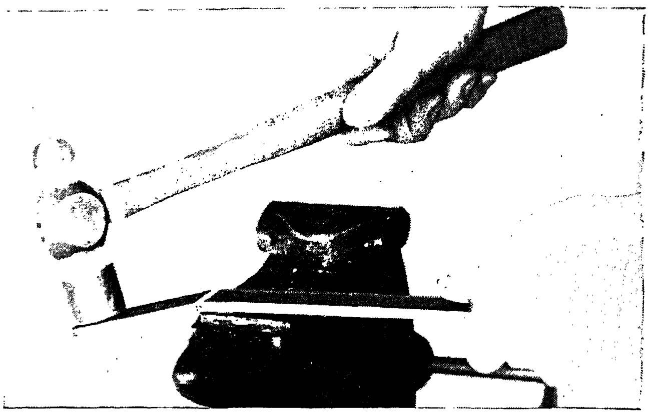

Fig. 119. Breaking off the bar after scoring with a cold chisel

ing the material back and forth at the cut, or by striking it with a hammer as shown in Figure 119.

Figure 120 shows how the chisel may be used to cut inside designs from flat metal. Lay out the design with a scriber, and place the metal, on which the design is to be cut, on a metal backplate. Cut the metal

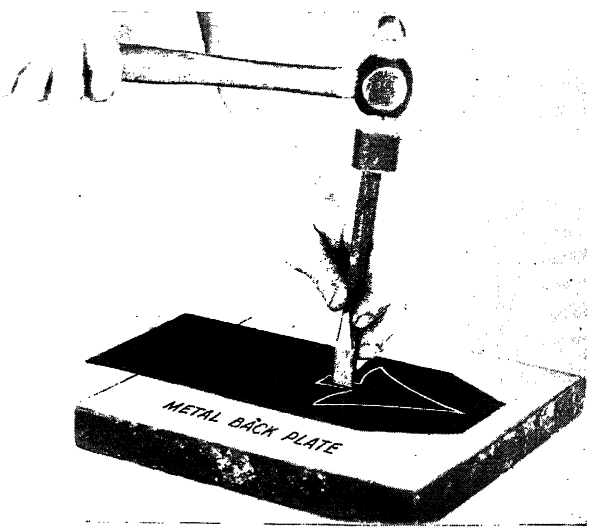

Fig. 120. Cutting an inside design with a cold chisel

just inside the finished layout. When the design is roughly cut to shape, file the edges smooth. Outside shapes may be cut in a similar manner, but the shearing process described in Method B might be easier.

A metal rod can be cut by notching it all the way around with a chisel and finally breaking it by bending or by striking with a hammer in the same manner as for flat bar metal shown in Figure 119.

METHOD B: To Cut with Vise and Cold Chisel

Tools: Vise; cold chisel.

1. Clamp the Metal in a Vise

Set the line for the cut even with the top of the vise. Place the edge where cutting begins between the jaws, and clamp the metal securely in place.

2. Hold the Chisel at the Proper Angle (see Fig. 121)

Holding the chisel at the proper angle is the most important operation of this procedure. The chisel should be high enough so that the bevel of the edge rests quite flat on the vise jaw. If held too high, the chisel

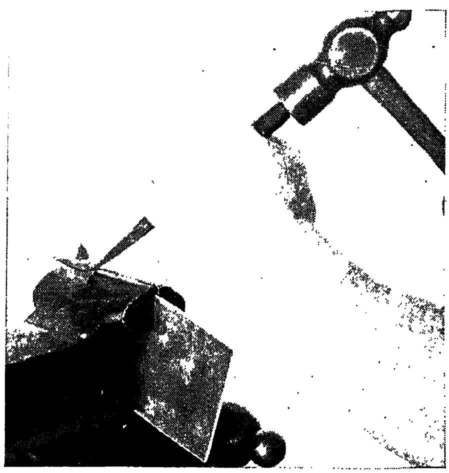

Fig. 121. Shearing with a vise and a cold chisel

will cut into the opposite jaw and damage it. If held too low, the metal is not sheared but only bent and torn. The chisel also should incline slightly backward. The cutting is done mainly with the center of the cutting edge and not with the forward point.

3. Shear the Metal

Begin at the edge of the piece that is between the jaws, and strike the chisel a heavy blow with a hammer. The blow should be hard enough so that the metal is cut all the way through. As the metal is cut through, advance the chisel for the next blow. Do not allow the forward

point of the chisel to do the cutting. If the piece of metal is longer than the vise jaws, reclamp and continue cutting as before.

Figure 122 shows this method of shearing applied to thin sheet metal. It is especially adaptable for making rectangular openings as shown in Figure 122.

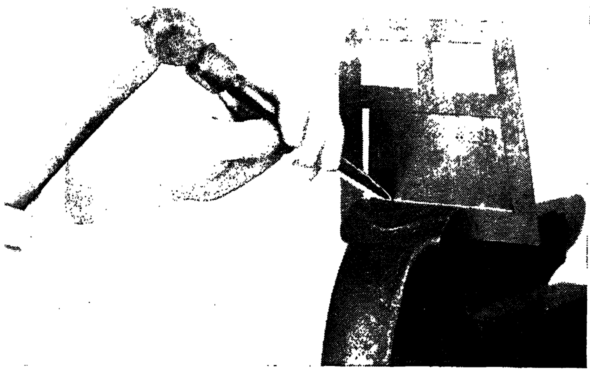

Fig. 122. Shearing windows for a porch lantern

Practice in shearing will develop skill. Study the proper angle for holding the chisel, and, if possible, have someone check your effort. Take special pains not to cut the opposite jaw and damage it. A clean, smooth cut with no burrs is an indication of a good job.

METHOD C: To Shear with Vise and Monkey Wrench

Tools: Vise; monkey wrench.

1. Clamp the Metal Bar in a Vise

Fasten the bar to be sheared in a vise, with the line for the cut flush with the top or the side of the jaws. Short pieces usually are clamped

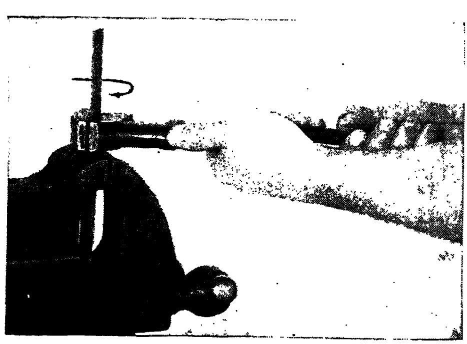

Fig. 123. Shearing a metal bar with a vise and a monkey wrench

in the center of the jaws as shown in Figure 123. Long pieces may be clamped horizontally. It is well to screw up the jaws tightly. Do not attempt to shear a piece larger than ¼ by 1 in. by this method.

2. Attach the Wrench

Adjust the monkey wrench as shown in Figure 123. The wrench should be clamped snugly to the metal bar and rest tightly against the jaws of the vise.

3. Twist the Bar

Grasp the wrench at the end and twist the bar through an angle of about 90 deg. The bar will shear at the junction of the vise and the wrench. A long wrench with sharp jaws and a vise with sharp arrises will make shearing quite easy.

METHOD D: To Cut with the Bench Lever Shear

Tool: Bench lever shear.

A bench lever shear, if available in your shop, is a convenient tool for rapid and easy shearing. Figure 73 shows a typical bench shear. The average capacity of such a machine is ⅛-in. sheet iron or bars 3/16 by 1 in. Do not attempt to cut heavier material than your machine is designed to cut.

To cut the metal with a bench shear, raise the hand lever as high as possible, and insert the piece to be cut tightly into the throat of the shear. Pull down on the lever to make the cut. For long cuts, do not entirely close the jaws, but raise the lever and advance the metal for continued cutting.

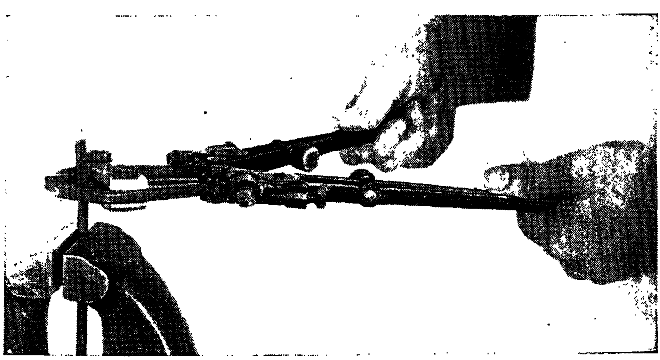

Fig. 124. Cutting a soft rod with a bolt clipper

METHOD E: To Cut with Pliers, End Nippers, or Bolt Clippers

Tools: Pliers; end nippers; bolt clippers.

The combination pliers and end nippers are convenient for cutting small wire and nipping the ends from small rivets and bolts.

A 14-in. bolt clipper of ¼-in. capacity is shown in use in Figure 124. A 36-in. bolt clipper will cut soft rods and bolts up to ⅝ in. in diameter. Bolt clippers also are available in other sizes.

STUDY QUESTIONS:

1. Of what is a cold chisel made?
2. What is the proper angle for the bevel of a cold chisel?
3. How may inside designs be cut out?
4. How would you cut off round bars with a cold chisel?
5. How do you shear with a vise and cold chisel?
6. How can you shear with a vise and monkey wrench?
7. What is the advantage of a bench shear?
8. What is the use of end nippers? Of bolt clippers?
9. Name some materials that should not be sheared or cut with hand tools.

Unit 18

TO FILE METAL

Filing is a process of removing fine shavings from metal by forcing the cutting face of a file over its surface.

A file is a piece of hardened steel with its faces covered with a series of blades or teeth. Figure 127 shows a typical file with the names of the parts.

Filing is an operation which is often performed by the skilled mechanic. It is especially adaptable to fitting and finishing surfaces.

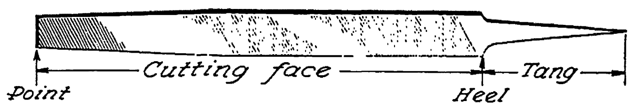

Fig. 127. Parts of a file

There are few mechanical operations more difficult than that of filing correctly. Since the file is guided entirely by hand, much practice is necessary to obtain good results.

Tools: File, file handle, file card, brush, and vise.

Material: Metal to be filed.

METHOD:

1. Arrange to Hold the Metal Securely

The material to be filed should be held securely, so that it will not chatter or vibrate. Small pieces are generally clamped in a vise, so that the part to be filed extends over the top edge of the vise. The work is best filed if it is on a horizontal line with the elbows.

2. Select the File

Files are made in different lengths, shapes, and cuts. The length does not include the tang. The shape refers to the cross section of the file.

The cut refers to the shape and size of the teeth. A coarse cut refers to large teeth and a fine cut to small teeth.

Common lengths used in the average shop range from 4 to 14 in. For small, delicate work use the shorter files. For general work select the longer files.

The job will determine the shape of the file to use. Some typical file shapes are shown in Figure 128. The mill file, which is a single-cut, flat

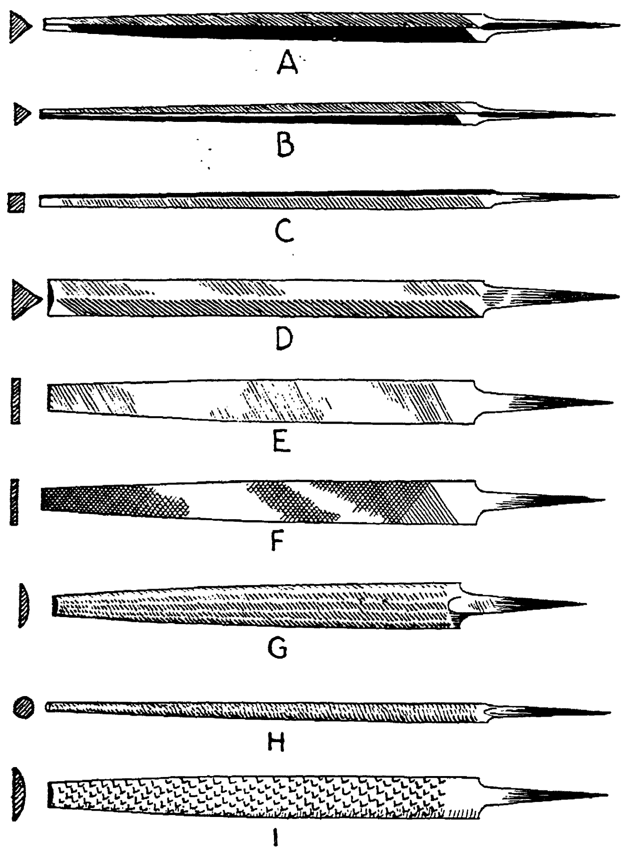

Fig. 128. Common file shapes. A, taper; B, slim taper; C, square; D, blunt band; E, mill; F, flat bastard; G, half round; H, round; I, half-round wood rasp

file, is the one used mostly for general filing. Figure 129 shows a square file used on an inside square. Other shapes are often used in the same manner.

Files are made in single cut, double cut, and rasp cut (see Fig. 130). The cut of a file refers to the way the rows of chisellike cutting teeth

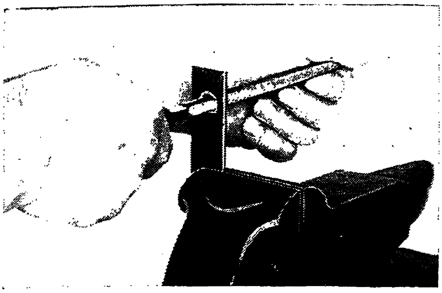

Fig. 129. Filing a round hole to a square

run across its surface. The single-cut file has cutting teeth running diagonally across the surface in one direction only. The cutting teeth on a double-cut file run diagonally from two directions, one set crossing the other. The rasp cut differs from either the single or double cut in that the teeth are separate and not connected with each other. Rasps are used by blacksmiths, plumbers, woodworkers, and others, for rough work, to remove a large amount of material.

The coarseness of teeth for both single-cut and double-cut files depends on the length of the file, and is indicated by the general terms, "bastard," "second-cut," and "smooth." The bastard cut is used for rough and rapid cutting. Select the bastard cut for initial cutting on cast iron, brass, bronze, and copper, and finish with a second-cut, a smooth, or a mill

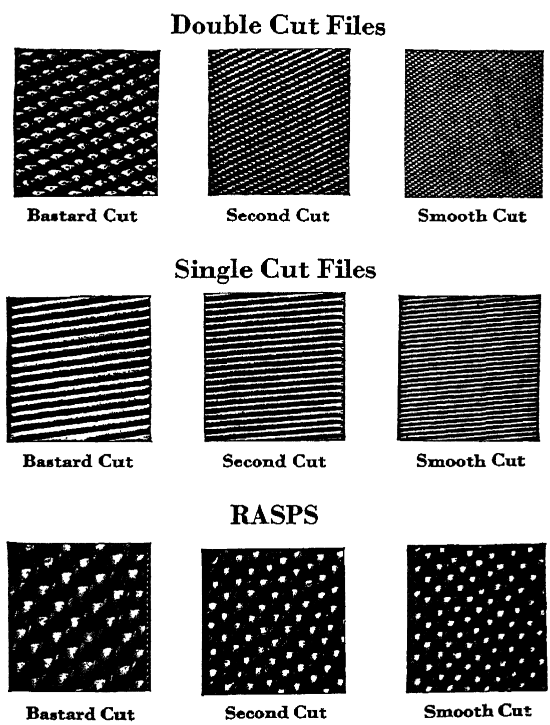

Fig. 130

file. The smooth-cut file is used for finishing surfaces. It has fine teeth and produces a smooth surface.

For soft steel, select a second-cut file, and finish with a smooth or finer file. For hard steel, select the smooth-cut file, and finish with a smoother cut, if available. For initial cutting on the softer metals, such as aluminum, lead, and babbitt, select the special coarse-cut files made for this purpose and then finish with a bastard or smoother.

Fig. 131. Always clean a dirty file before using

3. Clean the File

Before using a file see that it is clean. Figure 131 shows a file being cleaned with a file card and brush, working in the direction of the cut. The needle located in the card is used for removing any material that the card fails to clean out.

4. File the Metal Bar

A file always should be placed in a handle before using. A wood handle with a metal ferrule is recommended. Handles will prevent any injury to the hand from the sharp tang. Place the file tang in the handle, and strike the handle down on some solid object. This will set the handle firmly on the tang. Another type of wood handle is fastened by screwing it onto the tang.

Grasp the file as shown in Figure 132. Pressure should be applied to the file on the forward or cutting stroke only. Relieve the downward pressure on the backward stroke, sliding the file lightly back

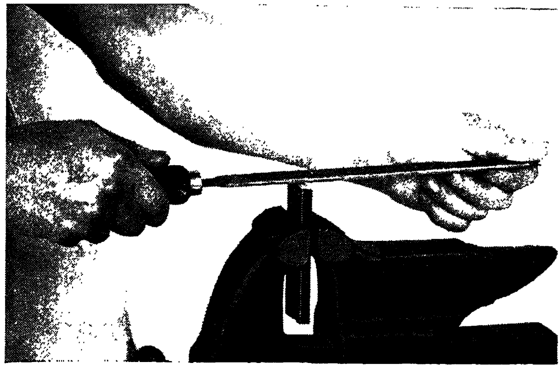

Fig. 132. Proper way of holding a file for filing

over the work. Sliding the file backward is useful when filing soft metals like lead or aluminum. Here drawing the file back along the metal on the return stroke helps to clean the teeth. The strokes should be deliberate and uniform. Make twenty to thirty strokes per minute. The strokes should be applied in such a manner to give a side as well as

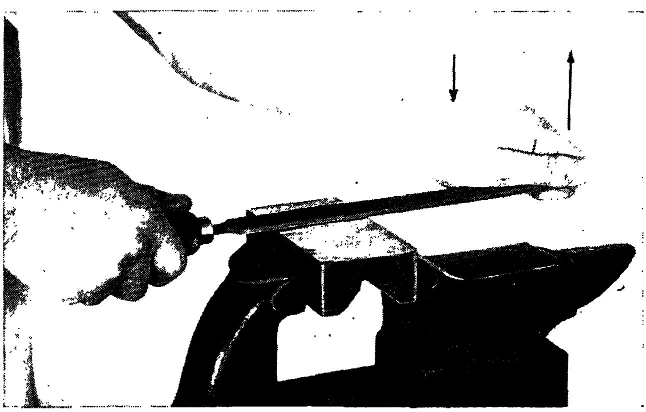

Fig. 133. Press down at the wrist and lift up at the end of the file when filing flat surfaces

a forward motion to the file. This side motion will uncover the surface filed as the stroke continues, and aid in examining or inspecting the surface during the process of filing.

For filing wide surfaces, it is suggested that the file be held as in Figure 133. Pressing down at the wrist and lifting up at the end of the file, as shown in Figure 133, will spring or bend the file slightly, and so prevent the corners of the work from being filed round. Using the file in this way will help greatly in filing a true, flat surface.

Drawfiling is a process of finishing and is not used to remove an excessive amount of metal. To drawfile, the material must be held securely. Where finished surfaces are to be clamped in a vise, it is advisable to use a sheet of copper over each jaw. This will protect the surfaces of the metal filed from being marred or scratched. Use a single-cut mill file for drawfiling, and be sure to place the file at right angles to the surface to be filed (see Fig. 134). Hold the file handle in the

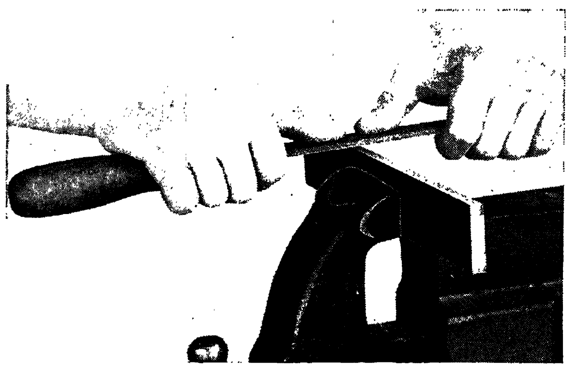

Fig. 134. Drawfiling a metal bar

right hand so the cut is produced on the forward stroke. The file should be held rigid and parallel to the surface being filed, and a uniform pressure applied on the cutting strokes, relieving the pressure on the return stroke. Care must be exercised at the beginning and end of each stroke to prevent excessive pressure, as this will cause the work to be rounded at the ends. The file must be cleaned regularly to prevent scratching. After drawfiling, if desired, a higher polish is obtained by rubbing the surface with fine emery cloth and oil.

STUDY QUESTIONS:

1. What is filing?
2. What metal is used for making files? Why?
3. Name the parts of a file.
4. Why must the metal be held securely for filing?
5. Files are made in what lengths and shapes?
6. Suggest a method of producing a square hole; a triangular hole.
7. Name the different file cuts, and indicate the meaning of cut.
8. Where are rasp-cut files used?
9. How are files cleaned?
10. Why use a handle on a file?
11. What is the procedure on the backward filing stroke?
12. Give directions for drawfiling.

Unit 19

TO GRIND A TOOL OR A PIECE OF METAL

The process of grinding has been used for a long time. The old-time grindstone that was slowly turned by hand or foot power is giving way to the more rapid power machines. However, hand grinders have been greatly improved. Figure 137 shows one type of modern hand grinder. By means of a system of gears, this hand tool is made to revolve very rapidly and it does very good work.

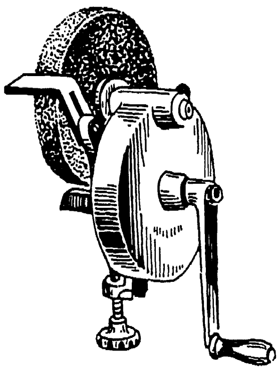

Fig. 137. A hand tool grinder

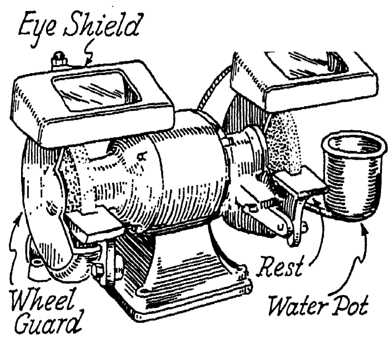

Fig. 138. A power grinder

Figure 138 shows a typical electric grinder that is convenient for the average shop. This grinder has a coarse and a fine wheel. The wheels are well housed so that the operator will be protected from flying particles. Glass shields for eye protection are supplied over both wheels. The rests are adjustable to different positions, and a water pot is provided for cooling the work being ground. The electric motor is started or stopped by merely pressing the proper button.

The old-time grindstone was a piece of natural stone. The rapid grinding wheels used today are artificially made. They consist mainly of carborundum or artificially made emery. These two hard substances are ground to fine grains and then are cemented together in various forms such as wheels, whetstones, etc., with some kind of binder. Some of the common binders are clays, bakelite, shellac, and rubber. If coarse grains are used, the wheel is intended for rough grinding. The very fine-grained wheels are used for finish grinding.

Tools: Grinder; goggles or eye shields (wheel dresser, if necessary).
Materials: Water; tools or metal to be ground.

METHOD:

1. Select the Wheel

Many grinders have two wheels — one for coarse work and the other for finish grinding. The coarse wheel has large pores and appears rough, while the fine wheel has small pores and presents a smoother surface. Select the coarse wheel for rough and rapid cutting, and the fine wheel for fine or finish grinding.

If the grinder at hand has only one wheel, of course there is no selection unless extra wheels are available that can be substituted for the one on the grinder. In case a great deal of one kind of grinding must be done continuously, it would be advisable to equip the grinder with the type of wheel most suitable for it.

2. Adjust the Rest (if necessary)

Most grinders are supplied with a rest which is an aid in supporting the work during the grinding process. A, Figure 139, shows the best position for the rest for average grinding. It is advisable to always check the position of the rest because the one using the machine previously may have moved it for special grinding. If you have special grinding to do, adjust the rest to suit, or, if necessary, remove it entirely. If the rest was removed or especially adjusted, replace it to the proper position for general grinding, when through. Check it for both clearance and height. Make a special effort to keep the rest close to the wheel and within the limits indicated in A, Figure 139. If the tool-grinding rest is carelessly placed quite some distance from the wheel, work being ground might become wedged between the rest and the wheel and serious damage result.

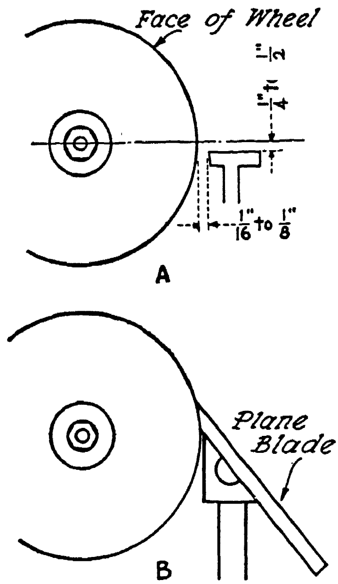

Fig. 139. A toolrest. A, suggested position of rest for general grinding; B, a special rest for grinding bevel-edged tools

B, Figure 139, shows a special rest for grinding bevel-edged tools.

3. Use the Eye Shield or Put on Goggles (see Figs. 138 and 140)

Many grinders are equipped with an eye shield for protection to the operator. It is very essential that the eyes be protected from the hot flying particles thrown from the wheel. The eye shield on the machine

Fig. 140. Always wear goggles when grinding if eye shield is lacking

is usually adjustable, and it should be properly placed between the eyes and the flying particles. If no shield is available, it is very important that you *put on goggles*. Failure to do this may mean the loss of eyesight.

4. Dress a Wheel (if necessary)

After a grinding wheel is used for a considerable time, the pores become clogged with particles of metal. Such a wheel is said to be "loaded." The face of a used wheel is also likely to become irregular, and possibly the wheel itself may get out of round from uneven wear.

To remedy the above defects, a wheel is "dressed" at intervals. This is done with a *grinding-wheel dresser*. The diamond dresser contains a

genuine diamond set in the end of a holder, and is used to dress wheels for very accurate work. Carborundum sticks, which do very accurate work, also are used to dress wheels.

The disk-type dresser, like the one shown in Figure 141, is the one most commonly used. It contains a series of sharp-pointed disks that revolve

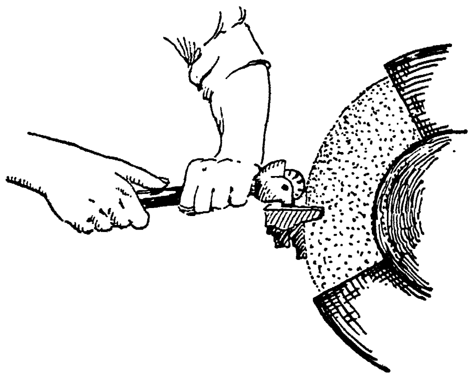

Fig. 141. Correct method of holding a disk dresser

rapidly and dig into the face of the wheel to remove loading and small bits of the wheel. These disks are inexpensive and are easily replaced in the holder.

To dress a wheel with a disk dresser, hold the disks firmly against the face of the wheel as it rotates at full speed. Move the rest far enough from the wheel to allow the heel on the underside of the dresser sufficient clearance. Hook the heel of the dresser on the inner edge of the tool rest during the operation. Move the dresser back and forth across the face of the wheel until the face is clean, straight, and true. After dressing the wheel, set up the toolrest to its proper position.

5. Prepare a Water Bath for Cooling

Water is useful for cooling metal that always heats during grinding. Cooling is especially important for tools with edges which may be burned or have the temper removed during the grinding. Many machines (see Fig. 138) are equipped with a convenient container for water. See that this cup is filled before starting to grind. If such a container is not supplied with the grinder, use a tin can, a small jar, or a pail for the cooling water.

6. Grind

Remember to protect the eyes. Use the face of the ordinary wheel, not the sides, for grinding. If for any reason side grinding is necessary, special stones should be provided.

Make use of the rest, if possible, for supporting the piece being ground. It serves as a guide as well as a rest for the work. Be sure to have a firm hold on the piece being ground. Carefully and gradually bring the work in contact with the wheel. Hold it solidly to the rest so that it does not vibrate or chatter. Move the work back and forth across the face of the wheel. This prevents wearing grooves in the face of the wheel. When the work gets warm, dip it in water for cooling.

Take special pains when grinding an edge tool. Check often to get the proper bevel and prevent heating. Undue heating will ruin an edged tool.

STUDY QUESTIONS:

1. Is the common grindstone a natural or an artificial piece of stone?
2. Are the grinding wheels today mainly natural or artificial stones?
3. Name two substances commonly used in the manufacture of grinding wheels.
4. State, in a few sentences, how grinding wheels are made.
5. State the proper position of the rest for average grinding.
6. What is used for eye protection during grinding?
7. Name several types of wheel dressers in use.
8. What part of the wheel only should be used during grinding?
9. State some rules relative to the grinding of metal pieces.
10. What care should be exercised during the grinding of edge tools?

Unit 20

TO ORNAMENT METAL

The ends of bars in a metal project can be left square and the surface left plain, but a more pleasing effect can be obtained by shaping the ends, and in some cases hammer-marking the surface. End construction, as well as surface marking, offers a considerable opportunity for originality in metalwork.

Hammer-marking is a carry-over of handwork from the early craftsman. Many of the objects were then fashioned by hand, leaving a more or less hammered surface. In our attempt to imitate this early craftsmanship, we possibly exaggerate these hammer marks. This is done in order to make the surface outstanding. Iron, copper, and brass are the metals usually ornamented by this process, because these are the metals commonly used for constructing projects.

Tools: Peen hammer, cold chisel, file, and anvil.

Material: Metal to be ornamented.

END FORMING

If the ends of bars are to be ornamented, do it immediately after the part has been cut to length. Figure 144 shows a number of suggested

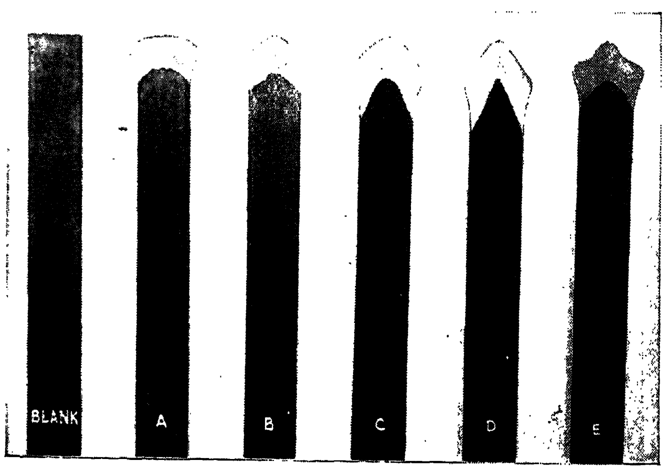

Fig. 144. Suggested terminal ornamentation for metal bars

designs for end construction on metal bars. Select the design you think best suited for the project, or develop a design of your own.

The end is first shaped with a file, grinder, or chisel. This original shaping determines the general outline of the form to a great degree, although not entirely. The amount of hammering on the surface also helps to determine the final shape. The idea is to file or grind the ends to the general shape desired.

The end is then hammered to give the final form. Metal bars up to 3/16-in. in thickness can all be hammered cold. Figure 145 shows the

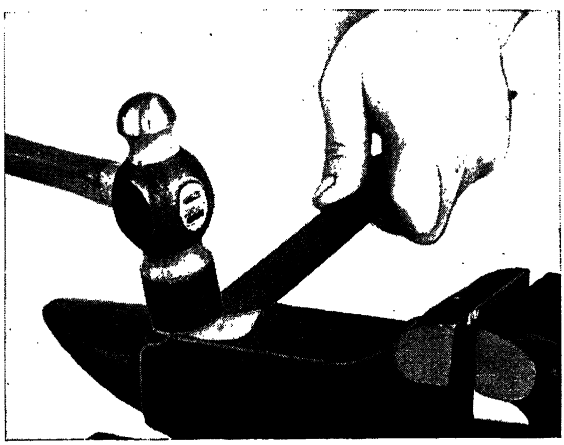

Fig. 145. Forming an end by hammering

method of hammering on an anvil. Note particularly how the bar is placed near the edge of the anvil. This prevents chipping or nicking the face of the anvil and the hammer.

Square and round pieces of metal up to ⅜ in. in thickness can be shaped in like manner. Remove any excess material by filing or grinding, and then hammer to final form if necessary. See Figure 146 for suggestions of end designs on round and square bars of metal.

Terminals made of brass and iron can be bought on the market. It is best, however, to form your own. They will then be in keeping with the rest of the construction. In Figure 146 several designs are shown which are shaped separately and then added to the piece.

MARKING THE SURFACE

Figure 147 shows the method used for ornamenting the surface of iron with the ball of a peen hammer. The effect produced with a cross-

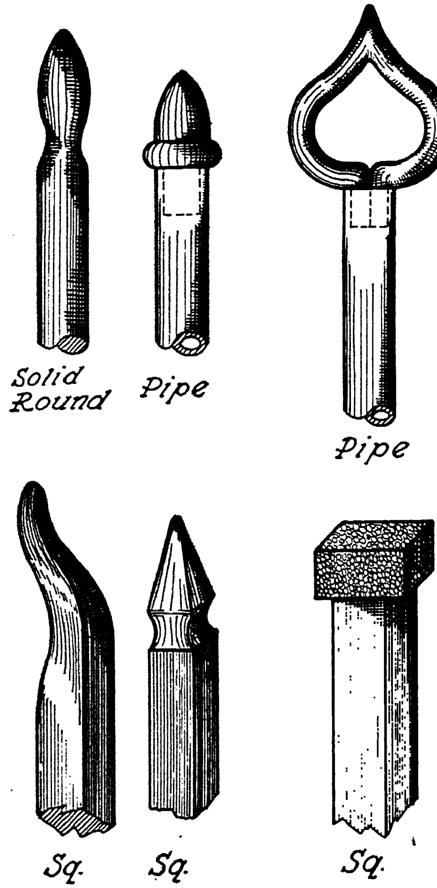

Fig. 146. Suggested terminals for round and square rods

peen hammer is shown in Figure 148. Select a punch or chisel for making any special marked designs that you desire.

Use some solid backing, such as an anvil or a metal backplate, when marking a heavy piece of metal. The hammer marks generally are close and overlapping, an example of which is shown in Figure 147. When all the surfaces of a piece are to be hammer-marked, the finished surfaces are protected by the use of a lead plate beneath the piece while marking the opposite face.

For marking thin metal, a series of shallow and deep marks frequently are used. To obtain such a surface, use a piece of lead or a block of wood as a backplate. Figure 149 shows the shade of a table lamp marked by this method. Note the marking is widely spaced and of irregular depths to produce this effect.

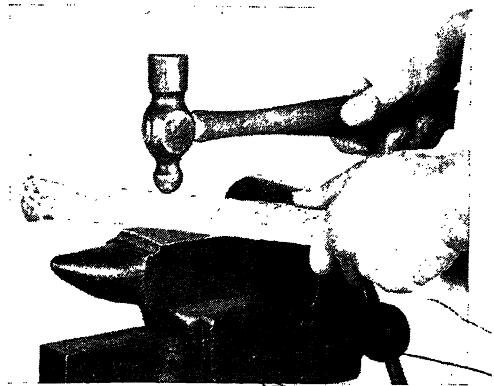

Fig. 147. Marking the surfaces of a metal bar. Note that the end is formed

Fig. 148. A, a flower-pot bracket, and B, a door knocker, showing the effect of hammer-marking

Fig. 149. Table-lamp shade marked with shallow and deep indentations

STUDY QUESTIONS:

1. State the two steps in end forming.
2. Where is the metal bar placed on the anvil for hammering the ends?
3. How did hammer-marking originate?
4. What metals frequently are hammer-marked?
5. Name two hammers used in hammer-marking.
6. How may a hammer-marked surface be protected while marking the opposite side?
7. How are heavy indentations produced in thin metal?

Unit 21

TO APPLY A FINISH

When common, bright metals are allowed to remain in contact with the air and moisture for some time, a dull coating forms on the surface. This coating is the result of chemical action and is often referred to as "corrosion" or "oxidation." Most of these coats consist of oxides formed by the oxygen of the air and water uniting with the metal. Iron becomes coated with iron oxide (rust), copper with copper oxide, etc. Therefore, most metals will corrode unless covered with some protective coating.

If we wish to preserve the original brightness or color of the metal, a clear or transparent covering is applied, which must keep out air and moisture. For protection against corrosion, colored paints, enamels, and lacquers are used. These colored coatings are also used to furnish a pleasing finish as well as a protection.

The surface of metal, therefore, is finished to preserve it or to produce a better appearance.

Sometimes metal is treated to produce an aged appearance. Projects made from iron are often oxidized with heat to produce this effect. Hammer-marked surfaces are treated by applying a coat of dark enamel or lacquer. After the enamel is dry, the finish is removed from the raised portions with some abrasive leaving the depressions dark. The whole surface is then covered with a clear or transparent covering. This treatment is sometimes spoken of as an "antique" finish.

Other metals, such as copper, brass, and bronze, are treated with chemicals to produce an aged appearance similar to that which would form naturally. This treatment of the surface also helps to preserve the metal, since the coating formed prevents further corrosion.

Tools: Brushes; rags; emery paper or emery cloth.

Materials: Finish to be applied.

TO APPLY AN OPAQUE FINISH

(Colored Enamel or Colored Lacquer)

It is important that the surface to be finished be free from oil or grease. Remove any such greasy material, and then, with a file or emery cloth, remove all roughness to obtain a smooth surface. It is essential that the surface be thoroughly clean before applying any finish.

Enamels cover the surface with an opaque coating, and for the beginner they will give good results. They apply easily and do not dry as rapidly as lacquer. Apply the enamel with a medium-soft brush, uniformly over all surfaces. Inspect the surface covered, and avoid sags or runs by smoothing out with the empty brush. Smoothing out is possible since the

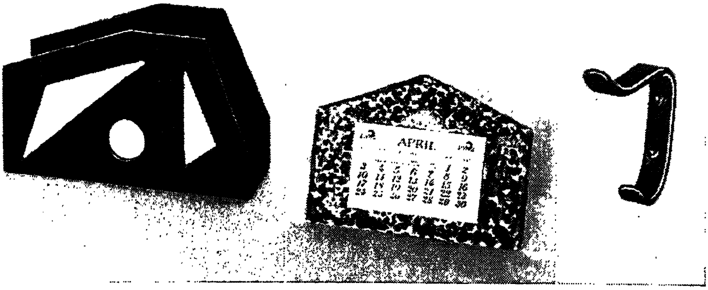

Fig. 152. Letter holder finished with colored lacquer; calendar holder finished antique; clothes hook finished with black lacquer

enamel does not set immediately. Flat-drying paints or enamels are recommended. A glossy surface may give a cheap effect to metalwork, particularly to wrought-iron work. Much of the hardware purchased today is covered with a black enamel and is said to be "japanned."

Brushing lacquer must be applied rapidly to the surface with a full brush. Rapidity is necessary because lacquer sets so quickly. Apply the lacquer to the surface as uniformly as possible with the first brushing, refilling the brush with lacquer and attempting to keep the edge of the coat wet at all times. This will prevent overlapping between brush strokes. If the edge of the applied coat is allowed to set, the next brushful of lacquer produces a double coat at the overlapping edge. It is best not to attempt smoothing out or touching up lacquer for this reason.

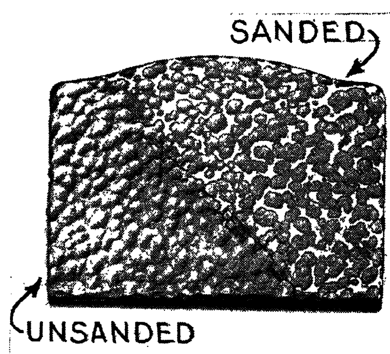

Fig. 153. Partly finished calendar holder showing the effect of sanding to produce an antique finish

Hammer-marked surfaces are oftentimes enameled or lacquered with a black coat. When dry, the finish is removed from the high spots with sandpaper or emery cloth, and a natural or transparent coat is then

applied over the entire surface. Figure 153 shows the production of this finish.

TO APPLY A NATURAL OR TRANSPARENT FINISH

The original appearance of a metal is retained by applying a clear or transparent coating. For this natural finish, wax, shellac, banana oil, linseed oil, or clear lacquer is applied. Oftentimes the surface of iron is brightened by removing all scale and oxide with a wire buffer, file, or

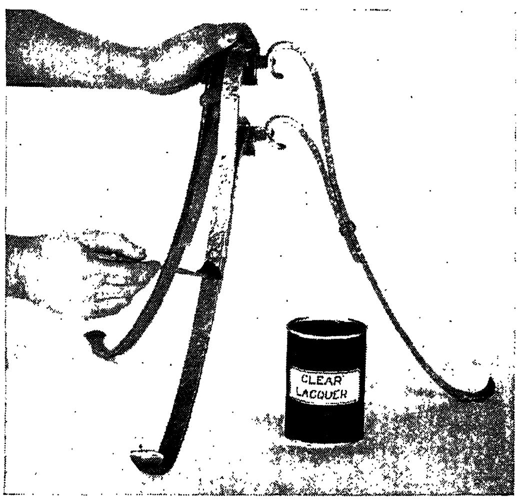

Fig. 154. Applying a transparent finish with a clear lacquer

emery cloth, and then coating it with a transparent finish.

Copper and brass are often polished to a high luster and then are coated with one of the transparent materials.

Common floor wax gives a quick but rather temporary natural finish. It is applied with a rag, allowed to dry several minutes, and then is polished by rubbing with a rag.

Shellac, banana oil, and clear lacquer should be applied with a very soft brush. The liquid should be thin and free-flowing to insure a uniform coating without laps (see Fig. 154). If clear lacquer is applied, follow directions for its application given in Method A. If oxidized iron is to be clear-lacquered, it is best not to add any oil to the surface during oxidation. Use only the lacquer for the coating. Sometimes lacquer is sprayed on with a small hand sprayer.

Linseed oil is sometimes applied to iron to give a transparent coating.

If used, it must be allowed considerable time to dry. A linseed-oil finish is not very durable.

TO PRODUCE AN OXIDIZED FINISH

For best results the metal should be clean and bright.

Iron products are best oxidized with heat. A gas flame, the blowtorch, or the forge may be used for this purpose. Heat the brightened surface of the iron slowly in the outer portion of the flame (see Fig. 155). The

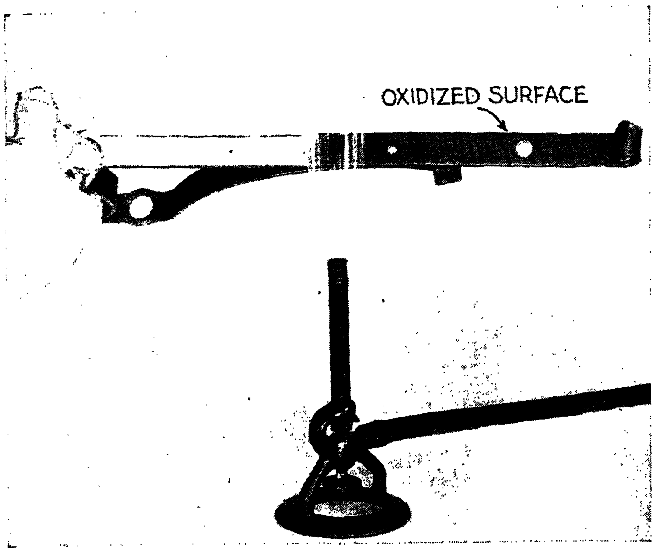

Fig. 155. Oxidizing a floor-lamp bracket with a Bunsen burner

iron will take on colors from a straw yellow to violet as heating progresses. The hot colored surface may then be treated by wiping on a layer of machine oil or linseed oil with a rag. Oiling at this time serves as a finish. To set these colors, the metal is then cooled in water. Large projects assembled with screws or bolts may be disassembled for oxidizing the parts more readily.

Copper and brass are oxidized in the most satisfactory and quickest manner by the use of chemicals. Oxidation is often assisted by heating the project slightly before applying the chemicals. The degree of oxidation is determined by the length of time the chemicals are allowed to work on the material. The surface must be free of oil and dirt before applying the chemicals, otherwise unsightly spots will be produced. Even finger marks left on the copper or brass may show up after the chemical is removed.

Liver of sulphur (potassium sulphide) applied to copper will produce colors from chestnut brown to almost black. Make a solution of the liver of sulphur in water and immerse the copper to be colored, or apply the mixture with a rag. A tablespoonful of liver of sulphur to a pint of water will give about the desired strength. The strength of the solution determines the darkness of the color. When the desired color is obtained, rinse the surface with water and allow to dry. Gentle heating will aid drying. Rubbing with a rag or even fine abrasive powders will remove some of the finish and give different colored effects. This may or may not be desirous.

To retain the various colored effects, apply one of the transparent finishes as described before.

STUDY QUESTIONS:

1. Why is the surface of metal finished?
2. What is an important rule for all finishing?
3. What are advantages in using enamel?
4. Why must lacquer be applied quickly?
5. How was the "antique" finish in Figure 153 produced?
6. What is a natural finish?
7. Name several transparent finishing materials.
8. How is iron oxidized quickly?
9. What colors can be given to iron by oxidation?
10. How is an aged finish quickly obtained on copper or brass?

Unit 22

TO MAKE SHARP ANGLE BENDS IN METAL BARS

It is frequently necessary to bend metal bars to form sharp angle bends. Bars ¼ in. and less in thickness are quite easily bent cold with the aid of a machinist's vise and hammer. A small vise will accommodate lighter material, but a larger vise is necessary for heavy material. A bar, ⅜ in. and even ½ in. in thickness, can be bent cold provided it is only bent a little. If it is necessary to make sharp right-angle bends in a bar heavier than ¼ in., it is advisable to heat it. This metal can be heated in the furnace used for heating soldering coppers.

Tools: Vise; hammer; monkey wrench.

Materials: Bars to be bent.

METHOD:

1. Lay Off for the Bend

Allowance must be made for the thickness of the metal when laying off for bends in material where accuracy is desired. The metal extending beyond the jaws of the vise must contain additional material in length to make the corner of the bend.

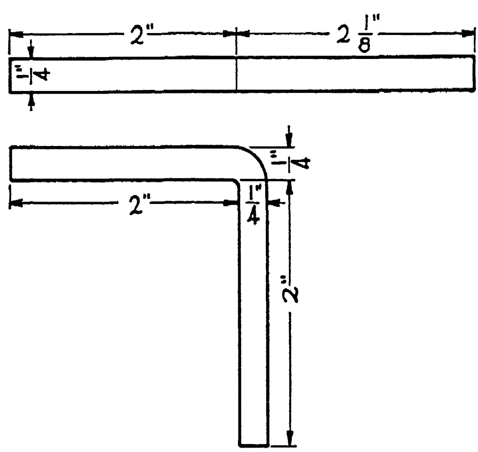

Fig. 158. Layout for bending a 2-in. corner brace from ¼-in. metal

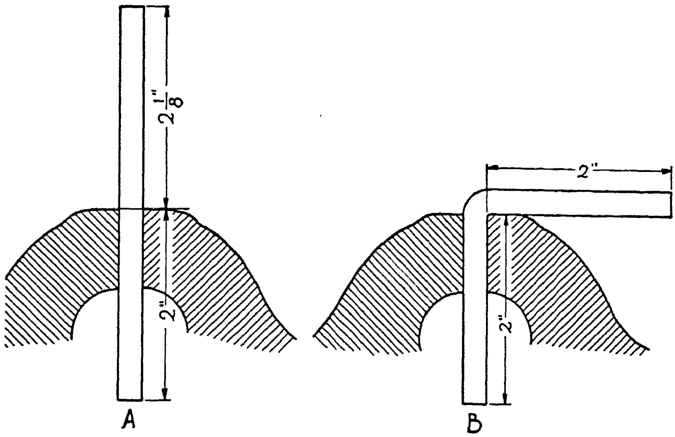

Fig. 159. A and B, order of bending a 2-in. corner brace from a ¼-in. bar

Figure 158 shows a layout for making a corner brace out of a ¼-in. bar. Here the rule of *adding half the thickness of the stock* to its length is applied. While not exactly accurate, this rule is sufficient where the metal is bent with a vise and a hammer. Note the allowance of ⅛ in. (which is half of the ¼-in. bar) that is added to the length of one arm of the brace.

Figure 159 shows how a corner brace is bent. Notice that the arm placed in the vise remains constant in length, while the arm outside of the jaw loses in length an amount equal to *half the thickness of the stock.*

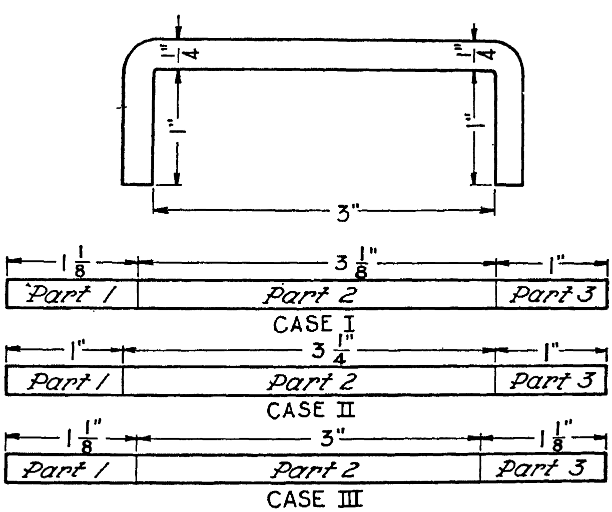

Fig. 160. U brace and different methods of layout

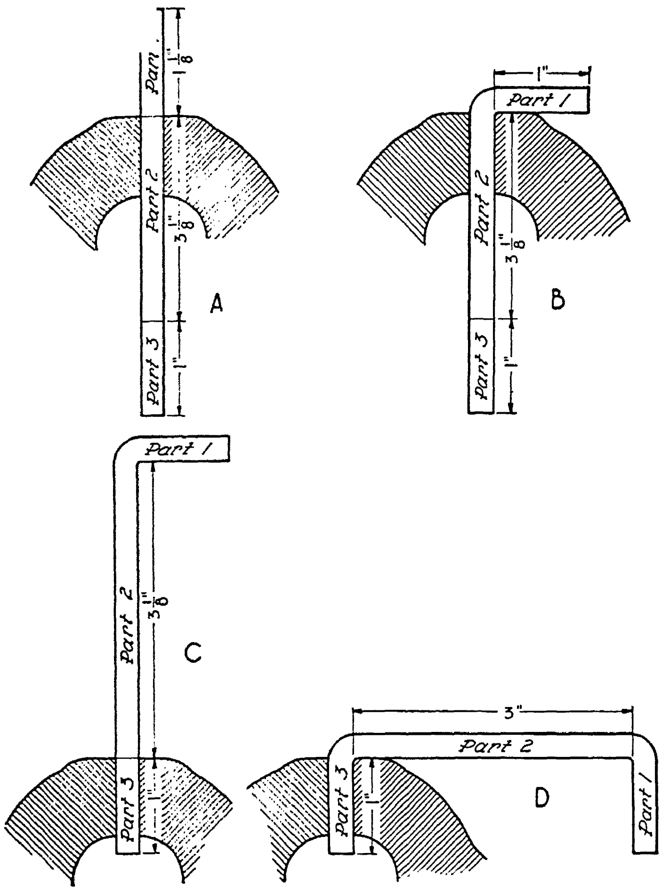

Fig. 161. Order of bending a U brace according to the layout in Case I, Fig. 160

If the over-all dimensions of a brace or project must be extremely accurate, the total thickness of the material must be carefully considered. This is added to the length of each arm that is bent. Note in Figure 158 that, while the arms of the brace measure only 2 in., the over-all dimensions are 2¼ by 2¼ in.

2. Determine the Order of Bending

If allowance for the bend is made in the layout, then the part to be clamped in the vise should be carefully noted. Remember that the part clamped in the jaws of the vise remains the same in length, and the part making the bend loses in length.

Figure 160 shows different layouts for the making of a U brace. The different allowances in the three cases shown are made for different orders

of bending, while the finished brace in each case is the same. When making more than one bend, it is advisable to carefully arrange the order in which these bends are made. Figure 161 shows the steps and the proper order of bending for Case I. In the other two cases, the order of bending is determined by the location of the allowance on the layout.

If a more complicated order of bending is necessary, the exact method should be figured out before the bending process is begun. The most important thing to remember is that *the part extending beyond the jaws of the vise loses in length an amount equal to approximately half the thickness of the material.*

3. Clamp the Metal Bar

When the order of bending is clearly in mind, clamp the proper part firmly in the vise. Short lengths can be placed in a perpendicular position

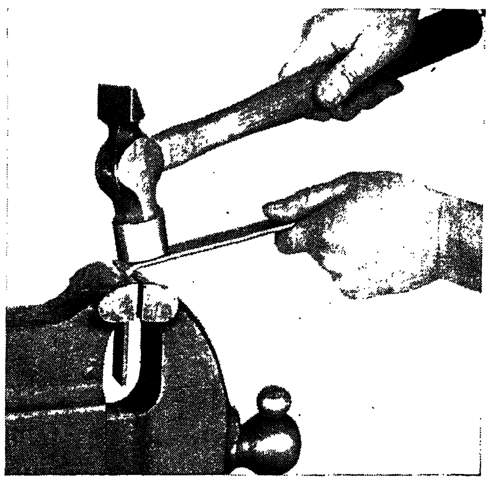

Fig. 162. Bending a metal bar
for a corner brace

as shown in Figure 162. It may be necessary to clamp extremely long lengths horizontally, as shown in Figure 163. When possible, clamp the bar in the center of the jaws and make a special effort to get it tight, as hammering may move it from its position and thus disturb the length.

4. Bend the Metal Bar

Use a peen hammer to make the bend. Strike the bar with light blows on thin material and heavy blows for heavy work. Begin the bend by striking with the head of the hammer slightly inclined toward the direction in which the bend is made. As the metal bends over to the proper

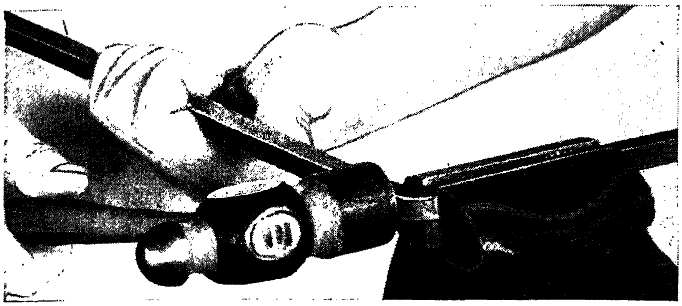

Fig. 163. Bending a long square bar

angle, confine the hammering as close to the bend as possible (see Fig. 163). Keep striking until the bend is square, but remember that too much hammering will reduce the bar in thickness. Test for the accuracy of the angle with a square or a pattern.

To bend metal less than 90 deg., proceed as before but stop when the desired angle is reached. Figure 164 shows how a monkey wrench

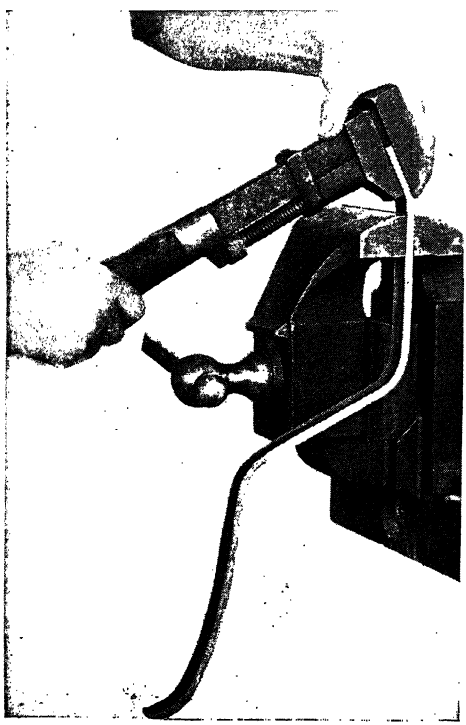

Fig. 164. Making a slight bend with a vise and a monkey wrench

can be used to make slight bends conveniently. In this illustration the bending of a leg for a floor lamp is shown.

To bend metal more than 90 deg., bend it to a right angle in a vise, then remove it from the vise, and with anvil and hammer close the right angle until the desired shape is reached.

STUDY QUESTIONS:

1. What tools may be used to bend sharp angles in metal bars?
2. When should you heat metal bars for bending?
3. Why must the thickness of the metal be considered when making a bend to accurate dimensions?
4. What is the *one half the thickness of the metal* rule?
5. What is meant by the order of bending?
6. State how you would bend a right angle.
7. How can you bend angles other than right angles?

Unit 23

TO TWIST METAL BARS OR SQUARE RODS

Sometimes it is necessary to twist metal pieces to change the position of the material so that a fastening can be made, or it may be twisted to give stiffness to the piece. A series of twists also has an ornamenting effect and is used in project construction (see Fig. 171).

Metal bars up to 1 in. in width and square rods up to ½ in. can be twisted cold with the aid of a vise and a monkey wrench. This is possible because mild steel is tough, malleable, and quite ductile. While the blacksmith of old was compelled to heat iron before shaping, now the average worker can form much of it cold from standard-shaped bars. If it is necessary to twist wider or heavier pieces, it is better to heat the metal. If a forge is not available, the metal can be heated in a common gas furnace which usually is found in the average metal shop.

Tools: Vise; monkey wrench (pipe guide, if necessary).

Material: Metal to be twisted.

1. Lay Out the Twist

Carefully measure and mark the limits of the twisted portion. For duplicate parts, these limits should be marked at the same time to insure equal lengths. Twisting a metal bar tends to shorten it somewhat, so for very accurate lengths allowance should be made. A piece of No. 10 by 1-in. strap iron will shorten about ⅛ in. for one complete turn. A piece the same thickness but only ½ in. wide will shorten about ½ this amount, and so other widths will shorten proportionally. Square rods shorten very little in twisting. If it is necessary to know the exact shrinkage for a special size of bar, twist a scrap piece one complete turn and measure the amount. In many cases such exact measurement is unnecessary.

2. Fasten the Bar in a Vise

Clamp one end of the bar in a vise so that one of the limit marks is in line with the outer edge of the jaws. Short pieces that are to be twisted only a quarter or a half turn may be clamped in a vertical position as shown in Figure 167. For twisting long pieces a complete turn or more, it is best to clamp the bar in a horizontal position (see Fig. 169). In either case the piece should be square with the jaws of the vise.

Fig. 167. Making a one-quarter twist in a short piece of metal

3. Determine Direction of Twist

Metal bars or rods can be twisted to the right or to the left. Duplicate parts should all be twisted in the same direction. If for any reason the twist should be right or left handed, determine this before the twist is

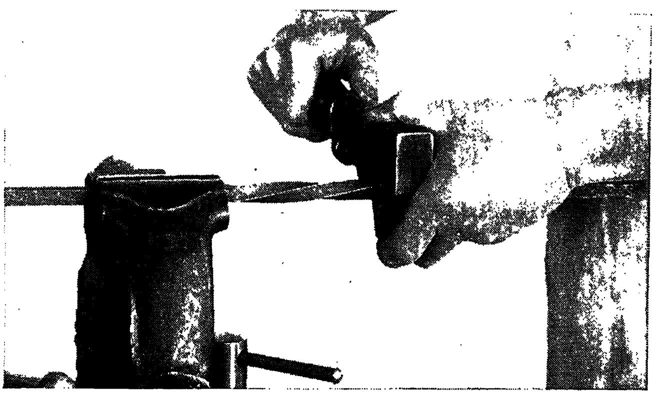

Fig. 168. Twisting a square bar one-half turn clockwise

begun. It might be interesting to know that if you twist the piece counter-clockwise, it produces a right-hand spiral similar to that in a sheet-metal screw or machine screw. Twisting the metal in a clockwise direction makes a left-handed spiral (see Fig. 168).

4. Twist the Bar or Rod

Attach a monkey wrench at the other limit mark. Screw the jaws of the wrench tightly together so they are square with the piece to be

twisted. Use one hand at the jaws of the wrench as a center (or guide) to keep the twisted portion from bending out of line. Note in Figures 167, 168, and 169, the left hand is serving this purpose, while the twist is made with the other hand. In Figure 167 only a quarter turn is made in a No. 10 by 1-in. bar. In Figure 168 a half turn is made in ⅜-in. square

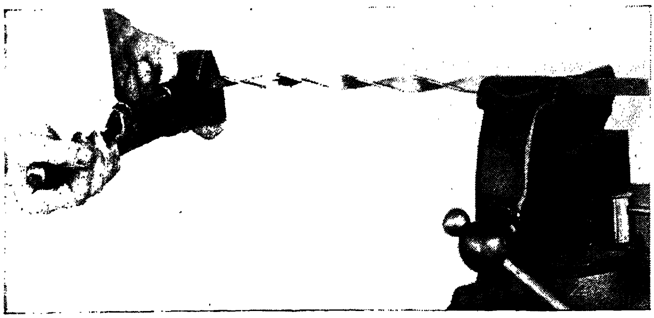

Fig. 169. Counterclockwise twisting in a horizontal position

metal, and in Figure 169 two complete turns are made in a No. 10 by ¾-in. bar.

For making long twisted portions, the beginner may use a pipe as a guide to keep the twisted piece straight (see Fig. 170). Cut a piece of

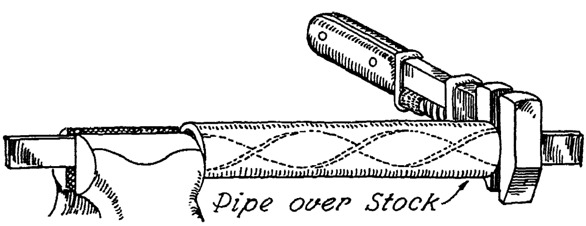

Fig. 170. Using a pipe for a guide while twisting a bar

pipe to the exact length of the twist and of a size to just slip over the metal to be twisted. Keep one end of the pipe in contact with the vise and the other end touching the wrench as the twist is being made.

STUDY QUESTIONS:

1. State several reasons for twisting metal pieces.
2. What common tools are used for twisting metal?
3. What size material can be twisted cold?
4. When twisting flat metal, what happens to the length?
5. What size bars or rods should be heated for twisting?
6. What kind of metal pieces remain about the same length even after twisting?

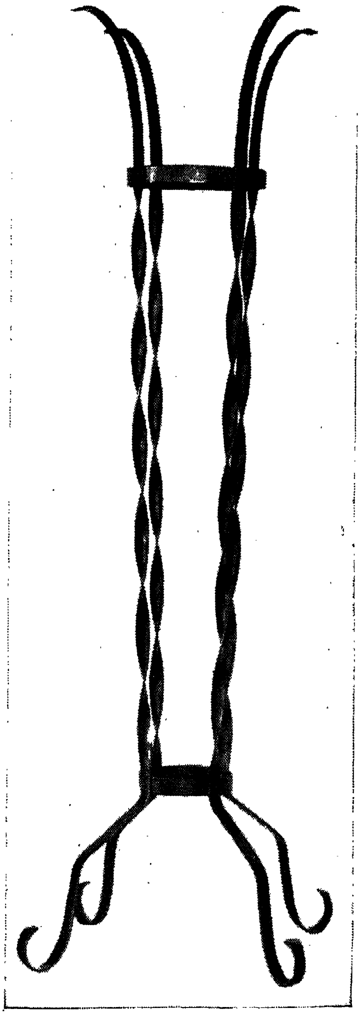

Fig. 171. Fern stand with twisted legs

7. How much would a No. 10 by 1-in. strap iron change in length if twisted three complete turns?
8. In what position are long pieces of metal usually clamped for twisting?
9. In what direction do you twist to make a right-hand spiral? a left-hand spiral?
10. When is a pipe used as a guide in twisting metal? What is its use?

Unit 24

TO BEND A SCROLL OR RING

In metalwork, parts may be curved to fit in particular places or to add to the appearance of a project. The making of lamps, brackets, stands, and many other projects requires the formation of curves.

Flats, squares, and rounds can be bent to form curves in a manner similar to that used in forming angle bends or twisting. The smaller sizes of metal bars or rods can be shaped cold.

In order to make a smooth curve, some form of bending jig is desirable. Numerous jigs have been assembled, but the type shown in Figure 176 is considered very useful for general bending of large and small curves. This jig also can be made from flat metal, for example, ¼ by 1 in. or ½ by 1½ in.

Figure 174 shows a decorative curve called a "scroll." This ornamentation has been in use for a long time. It possibly originated from the representation of a roll of parchment paper partly unrolled. The scroll is used a great deal by the sculptor, the carver, and the architect. The curved head of a violin and of many similar instruments takes the form of a scroll. The amateur workman will do well to note the characteristics of the scroll since it can be worked into many designs and projects. Note that the scroll is never a circle but a curve always changing its radius.

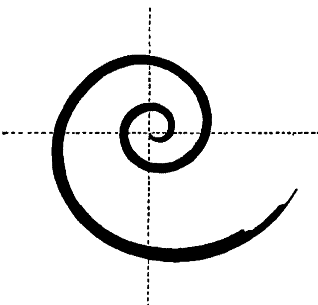
Fig. 174. A scroll

Rings can be constructed of flat, square, or round metal pieces. A ring frequently is used as the framework of a project.

Tools: Vise; bending fork; mandrel or pipe; hammer; cutting tools; and laying-out tools.

Materials: Metal to be bent or formed; template or pattern.

METHOD:

1. Cut the Metal Pieces to Length

Unit 1 gives several methods for measuring the length of curved pieces (see Fig. 7).

The circumference of a ring is the diameter times 3.1416 or times 22/7 (approximately).

2. Form the Ends and Hammer-Mark (if necessary)

If the ends are to be formed and the surfaces hammer-marked, this must be done before the pieces are bent (see Unit 20).

3. Prepare a Bending Jig

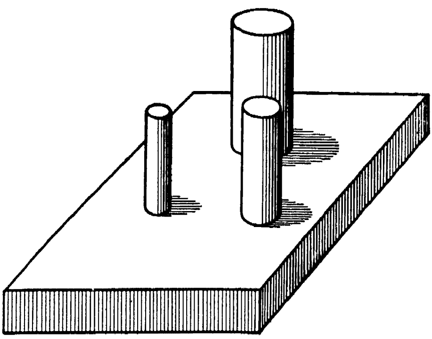

Fig. 175. Bending jig of steel dowels set in metal plate

Some kind of bending jig is necessary for bending the material. The open jaws of a vise make a useful jig at times. A monkey wrench clamped in a vise makes a convenient adjustable jig. Several steel dowels of various diameters set in a metal plate, as shown in Figure 175, make a combination jig that can be used for forming various curved shapes.

A serviceable jig for general bending is shown in Figure 176. This type is rugged and convenient. A similar jig with a round hole in a piece of square or hexagonal steel bar will bend round rods exceedingly well. The hole should be slightly larger than the round to be bent.

4. Make a Pattern

A model or a full-sized drawing of the curve is advisable. Either will serve as a pattern as the metal is bent to shape. Sometimes the mechanic lays out a full-sized drawing on the workbench or the floor with a piece of chalk and uses this as a guide.

5. Bend a Scroll (or Curve)

Clamp the bending jig tightly in the vise. Insert the end of the bar in the jig and bend it to the desired curve. Move the piece, and bend again. It is best to move the bar just a little after each bend. Check the curve frequently by placing it over the pattern. When one end of the curve is

formed, reverse the piece and start the curve at the other end (if this is to be curved). Note the position of the thumb that is adjacent to the jig (see Fig. 176). In light material, the thumb in this position will be useful to form a smooth curve.

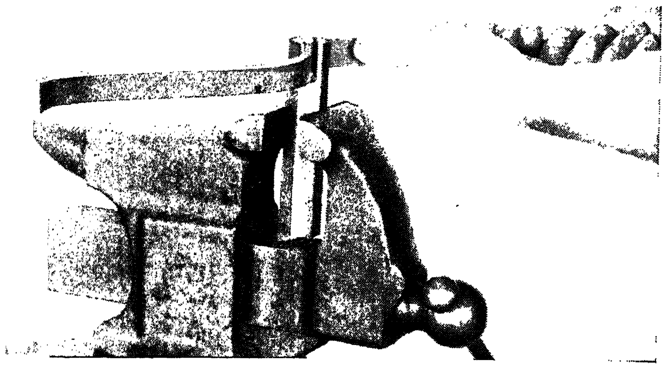

Fig. 176. A bending jig used to shape the curved portion of a leg for a floor lamp

6. Bend a Ring

Rings of large diameters can be formed with a bending jig. Start at one end and bend about one half of the ring, then reverse and bend the other half. Place the ring over the pattern or drawing of the proper-size circle frequently to test the curvature.

A hammer and a combination vise can be used to form a curve or ring. Figure 177 shows two methods. To make a ring, form the curve from each end and finally close it by bending near the center.

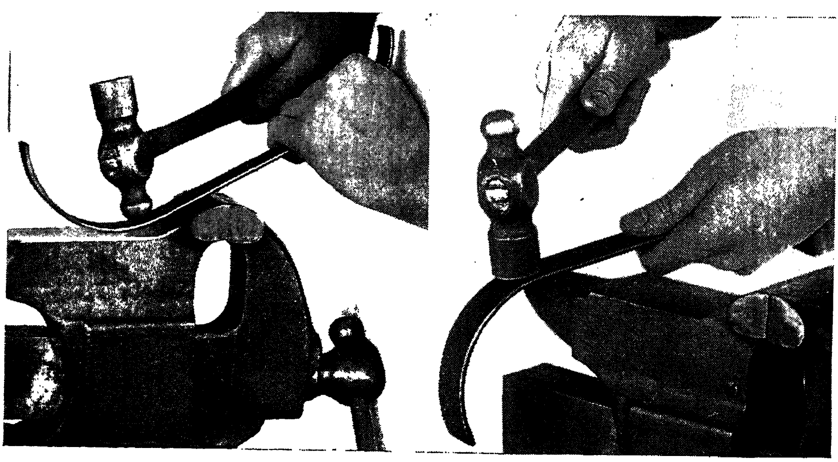

Fig. 177. Two methods of forming a ring or a curve without the aid of a jig

Figure 178 shows several methods for fastening rings used in project construction. They may be held together with rivets or be brazed as desired.

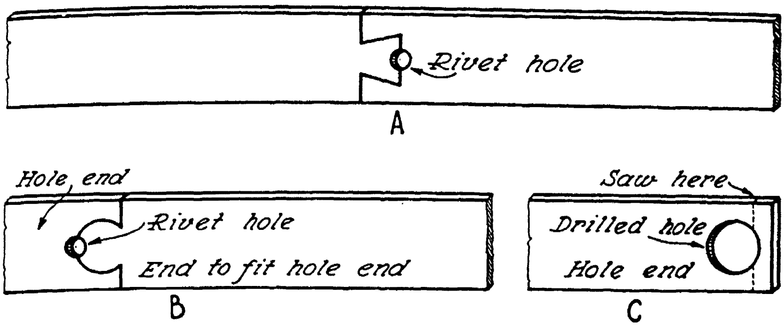

Fig. 178. A and B, suggested ring joints; C, detail of construction for hole end used for B-type joint. Rivet holes are drilled after joint is assembled

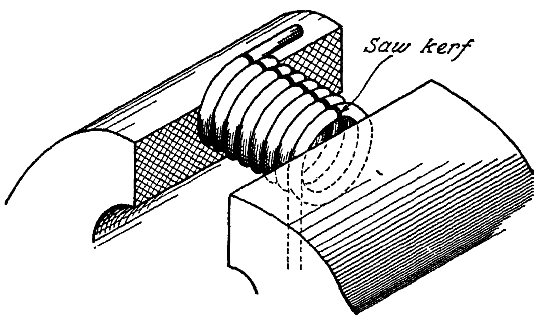

Fig. 179. Method of making a number of equal-sized rings from a coil

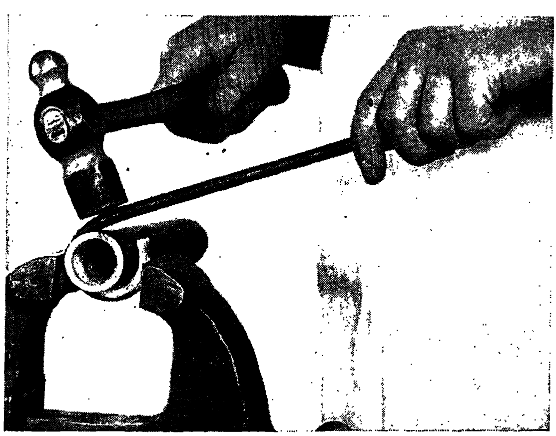

Fig. 180. Forming an eye with a vise, a mandrel, and a hammer

To make rings of small diameter, saw sections from a pipe of the proper size.

Small rings of round rods can be made by winding many turns around a mandrel and then cutting the coil into individual rings (see Fig. 179). Small rings of square rods also can be made in this way.

7. Form an Eye

Figure 180 shows one step in forming an eye with a mandrel and a vise. The successive steps are shown in Figure 181.

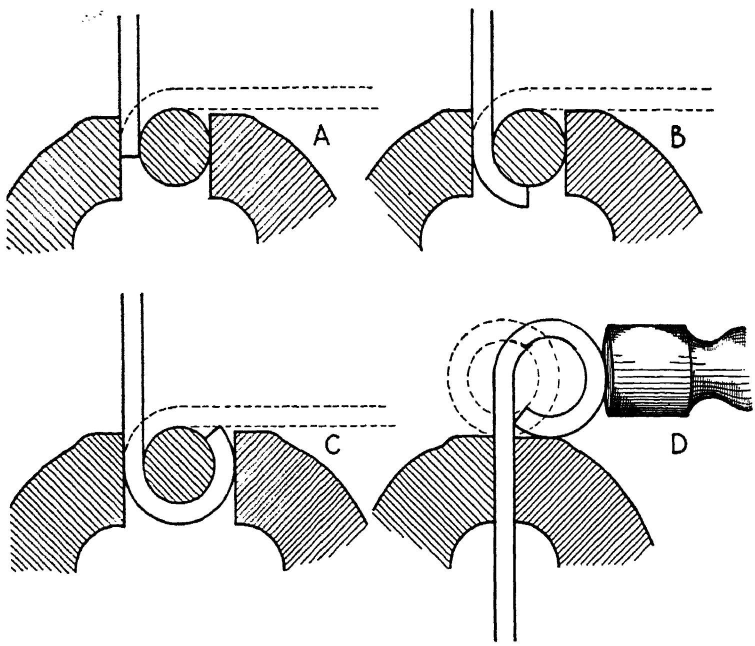

Fig. 181. Steps in forming an eye with a mandrel, a vise, and a hammer

STUDY QUESTIONS:

1. What are the uses of curved parts in a project?
2. Where did the scroll probably originate?
3. What is the use of a bending jig?
4. State several arrangements that make useful bending jigs.
5. Why use a full-sized drawing or pattern for bending curves?
6. Where does the mechanic sometimes make a full-sized drawing of his work?
7. State the procedure in forming a scroll.
8. State several methods of forming large or small rings.
9. State the procedure in forming an eye.

Unit 25

TO RIVET HEAVY METAL

Rivets are set in heavy metal by methods similar to those used for thin metal (see Unit 13). While tinner's rivets are used almost exclusively in sheet metals, a large variety of rivets are available for heavy metalwork.

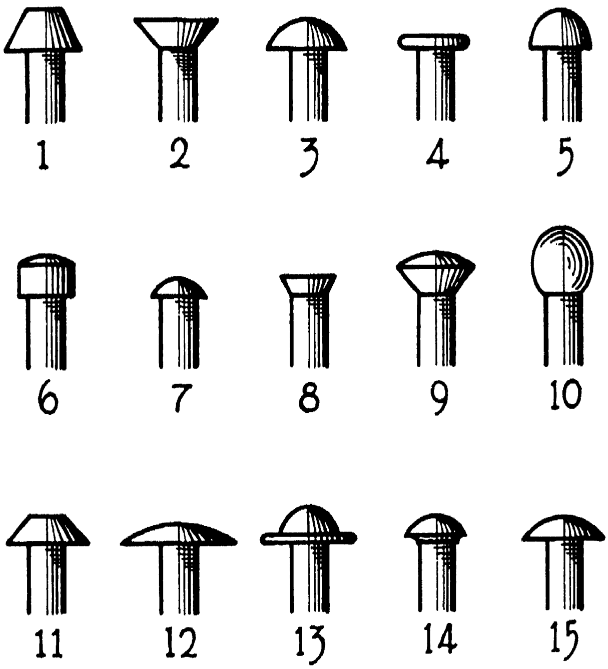

Fig. 184. Numerous rivet heads available. 1, Cone; 2, countersunk; 3, oval; 4, flat; 5, roundheaded; 6, fillister; 7, pin; 8, section; 9, countersunk oval; 10, ball; 11, pan; 12, wagon box; 13, washer; 14, shovel; 15, truss

Some of the numerous rivet-head types are shown in Figure 184. Several of these types are used for thin metal as well as for heavy materials. Cooking utensils which are made of thin metal, may have handles, ears, and hinges riveted on with pan, flat, or oval-headed rivets. The round head and the countersunk head are the ones generally used for heavy metal. The round head is used for strength and appearance and the

countersunk to make a flat surface. The other types shown are available for special purposes.

Rivets are manufactured in the common soft metals, as iron, copper, brass, and aluminum.

For average work the small rivets are headed cold. In structural-iron work, large rivets are inserted and headed hot. A hot rivet is easily and quickly headed, and, when it cools, the contraction of the metal draws the joint tightly together.

The size of rivets includes the diameter and the length. The length is taken from the underside of the head to the point in all rivets except the countersunk. The length here includes the head. Rivets are commonly sold in 1-lb. packages. They are also put in 3 and 5-lb. packages and 50- and 100-lb. kegs. The diameters of small rivets sometimes are made scant so they will readily enter the hole of the diameter given.

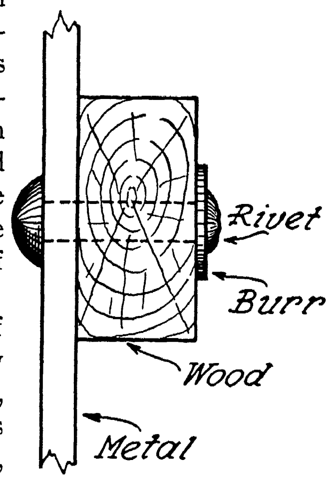

Fig. 185. A typical use for burrs

The washerlike disks used on the ends of rivets are called "burrs." They are necessary when riveting soft material such as leather, wood, etc., or when fastening these materials to metal (see Fig. 185). When ordering burrs, indicate the exact size of the rivet for which they are intended. Burrs are not just plain washers.

Tools: Punch or drilling tools; rivet set; riveting hammer; anvil or backplate.

Materials: Heavy metal to be riveted; rivets.

METHOD:

1. Select the Rivet

Select the type of head suitable for the job. Iron rivets are usually used in ironwork, but sometimes copper or brass rivets are selected with iron for decorative purposes. The projecting length necessary for heading a rivet should be from one to one and one-half times the diameter of the rivet (see Fig. 186). Select a diameter strong enough for the joint but not too large, since the necessary hole might weaken the pieces to be fastened.

2. Make the Holes

Lay out the position of the holes accurately.

In heavy metals the holes must be drilled or punched. The diameter of

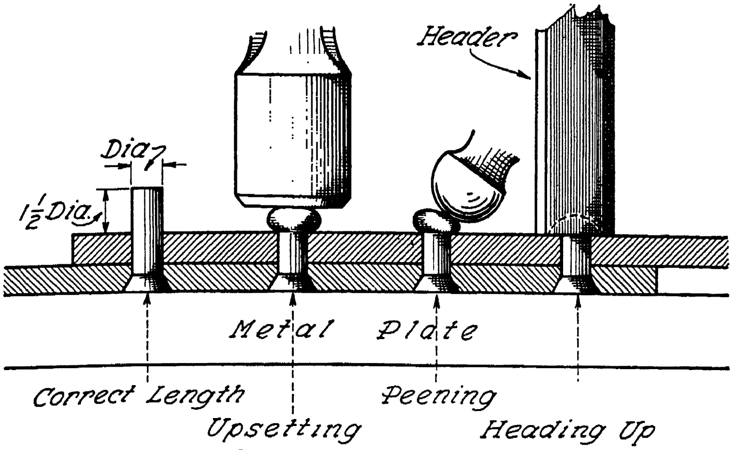

Fig. 186. Steps for heading round-headed rivets

the hole should be such so that the rivet will slip easily in place. A common allowance is 1/64 to 1/32 in. Countersink for a countersunk rivet at this time.

3. Insert the Rivet

Place the rivet in the hole, and check for proper diameter and length. If too long, the surplus can be removed conveniently with a nipper or bolt clipper.

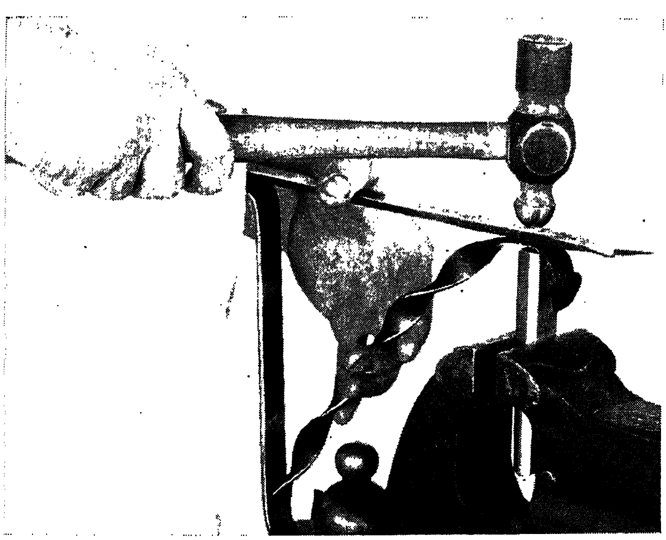
Fig. 187. Backing up a round rivet head with a rivet set for protection while riveting

4. Head the Rivet

Place the head on an anvil or any convenient solid plate of metal. If a round head is to be protected, place it in the hollow of a rivet set or special metal block. Strike the point of the rivet heavily to fill up the hole and upset the end (see Figs. 186 and 187). This spreads the rivet into a flattened head. The head can be formed round by shaping with the ball of a hammer, or better with a rivet set, as shown in Figure 187.

5. Remove a Rivet

A badly set or headed rivet can be removed as follows: Cut off the head with a chisel as shown in Figure 188, and drive out the rivet with a punch.

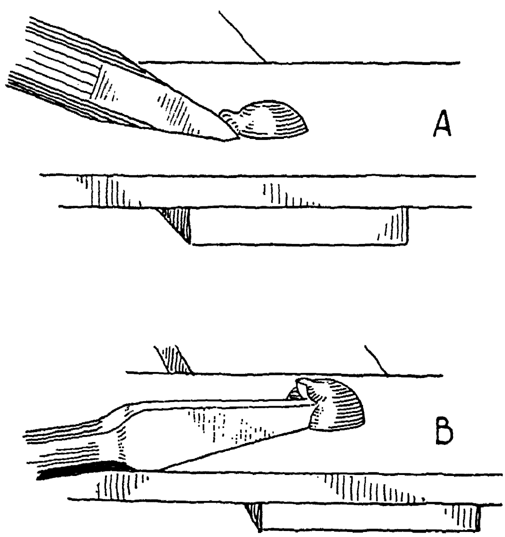

Fig. 188. Two methods for cutting off rivet heads for removal

To remove a rivet by drilling, which is especially recommended for sheet metal, use a drill slightly smaller than the diameter of the rivet and drill as near the center of the rivet as possible. Removal by drilling reduces the tendency to mar the surface with a chisel.

STUDY QUESTIONS:

1. Name some of the different types of rivet heads.
2. Are small rivets headed cold or hot?
3. What are the advantages of heading rivets hot?
4. How is the size of rivets indicated?
5. How are rivets usually sold?

6. Why are rivet diameters sometimes scant?
7. What is a burr and its use?
8. How much of the rivet stem should project for forming full round heads?
9. How is a rivet headed?
10. How may a badly set rivet be removed?

Unit 26

TO BRAZE A JOINT

Brazing is often spoken of as "hard soldering." It produces a stronger joint than soft solder, and in some cases a joint is as strong as the material brazed. Brazing is useful for repairwork and also in the construction of projects where a strong joint is necessary.

Brazing requires a much higher temperature than soft soldering, therefore a soldering copper cannot be used for heating or melting the spelter. Spelter, in the form of small pellets or granules, is the substance used to braze the joint. Spelter is composed of copper, tin, zinc, and antimony. The melting point of spelter ranges from 1350 to 1650 deg. Fahrenheit. The gas furnace, gasoline blowtorch, or forge may be used to produce the necessary brazing heat. A charcoal fire or a welding torch also furnishes excellent heat.

Two factors absolutely necessary for successful brazing are a *clean surface* and *sufficient heat*. The surface to be brazed must be kept from oxidation during the heating process. Borax or special fluxes are used for this purpose. When heated fluxes form a glasslike coating on the surfaces of a joint, it protects the spelter and stock from oxidizing. A clean, raw surface gives perfect union of the spelter to the metal.

"Special spelters" with the flux already added are now on the market. They can be had in high and low melting points. Follow any special directions supplied with such combinations for successful results.

The materials most commonly brazed are steel and iron in their various forms. Copper and brass also may be brazed, but lower-melting-point spelters must be used.

Tools: Any one of the following: gas furnace; gasoline blowtorch; forge; charcoal burner; or acetylene torch.

Materials: Borax or special flux; metal to be brazed; and spelter.*

*Note: For emergency, if spelter is not available, a piece of sheet brass may be cut, with a tin snips, into very small pieces and these used in place of the commercial spelter. However, the regular spelter is recommended for routine work.

METHOD:

1. Clean the Metal at the Joint

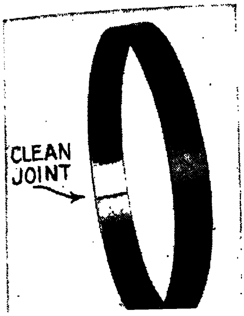

Fig. 191. A joint cleaned and ready for brazing. Fasten the joint together if it does not hold itself in place

Remove all dirt, grease, or oxide from the surface of the metal at the joint. This is best done by grinding or with a file. A wire buffing wheel also may be used for this purpose. Bright, raw metal at and around the joint is necessary for perfect brazing (see Fig. 191).

2. Fasten the Joint for the Braze

The joint must be held securely in place during the heating process. This is often done by binding with wire or fastening with clamps. A joint like that of a ring, which holds itself tightly together needs no fastening. The joint should fit tightly together and be in proper alignment.

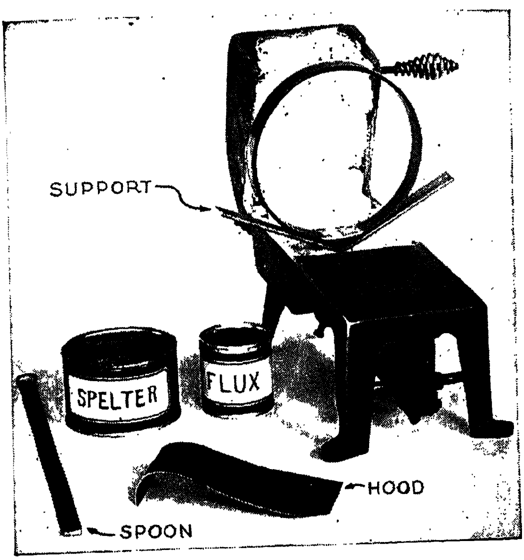

Fig. 192. A ring joint set up for brazing in a gas furnace

3. Braze the Joint

Select any of the available methods for heating the joint. Support the work so that the joint is centered in the hot part of the flame. Care must

be exercised to heat the parts of the joint to a uniformly high temperature. When heating with a gas furnace or a gasoline torch, a metal hood made from a piece of scrap sheet metal and placed directly over the joint will help to concentrate the heat (see Fig. 192). When the metal approaches a red heat add a quantity of flux to cover the joint. When the metal at the joint reaches a light-yellow heat, apply spelter over the surface. Use the smaller pieces of spelter as they melt more readily. Add a sufficient amount of spelter to fill the joint. Spelter can be spooned on with a long strip of strap metal while the joint is still being heated.

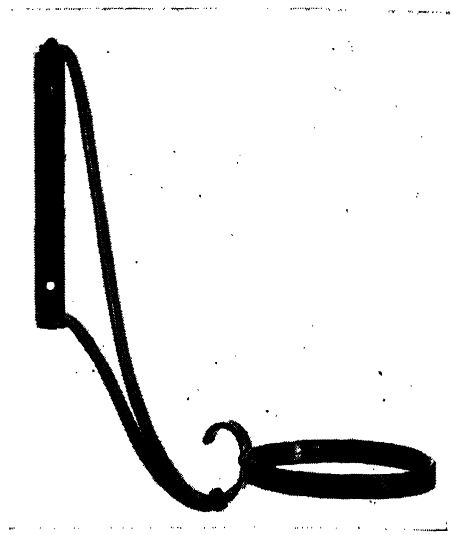

Fig. 193. Plant bracket using a brazed ring

Continue to heat the joint until all the particles of spelter are melted and the crevice of the joint is completely filled with molten spelter. A well-fused joint will show a smooth appearance on the outer surface of the metal around the joint. When this condition appears, remove the metal from the source of heat and allow it to cool. *Never quench a brazed joint in a liquid.* A final inspection may then be made and any surplus spelter removed with a file or a grinder.

STUDY QUESTIONS:

1. What is brazing and its use?
2. Does brazing require a high or low melting temperature?
3. What is spelter? Its composition?
4. How may a joint be heated for brazing?
5. What is the common flux used in brazing?
6. What are "special spelters"?
7. What metal is commonly brazed?
8. Give steps in brazing a joint.
9. How may the heat be concentrated while heating a joint?

Unit 27

TO TAP HOLES

It is necessary to drill and tap holes when machine screws, cap screws, setscrews, machine bolts, or the like, are to be screwed into metal. A hole is first drilled into the metal, and then a tap is turned in to cut the threads. The machine screw or machine bolt may then be turned into place. A small tap-and-die set is a handy tool for any workshop. Since holes are tapped to accommodate machine screws, some information about screws is useful.

The smaller machine-screw diameters are indicated by numbers, as 8, 10, 12, etc., and following each diameter number is given the number of threads to the inch. Thus No. 8–32 would indicate the gauge size (diameter) of a No. 8 screw with 32 threads per inch. For larger machine

Diameter of rod or tap	*N. C. Pitch*	*N. C. Tap-Drill Size*	*N. F. Pitch*	*N. F. Tap-Drill Size*
No. 0			80	3/64″
No. 1	64	No. 53	72	No. 53
No. 2	56	No. 50	64	No. 50
No. 3	48	No. 47	56	No. 45
No. 4	40	No. 43	48	No. 42
No. 5	40	No. 38	44	No. 37
No. 6	32	No. 36	40	No. 33
No. 8	32	No. 29	36	No. 29
No. 10	24	No. 25	32	No. 21
No. 12	24	No. 16	28	No. 14
¼″	20	No. 7	28	No. 3
5/16″	18	F	24	I
⅜″	16	5/16″	24	Q
7/16″	14	U	20	25/64″
½″	13	27/64″	20	29/64″
9/16″	12	31/64″	18	33/64″
⅝″	11	17/32″	18	37/64″
¾″	10	21/32″	16	11/16″
⅞″	9	49/64″	14	13/16″
1″	8	⅞″	14	15/16″

Fig. 196. Table showing standard number of threads and tap-drill sizes in both coarse and fine thread series for various diameters

screws, cap screws, and setscrews, the diameter is indicated in fractions of an inch, as 3/8 in., 1/2 in., etc. Figure 196 shows the national standard thread numbers in coarse (N.C.) and fine (N.F.) threads for diameters from gauge 0 to 1 in. in diameter. It also gives the proper tap-drill sizes in both series for a 75-per-cent depth of thread. The coarse threads

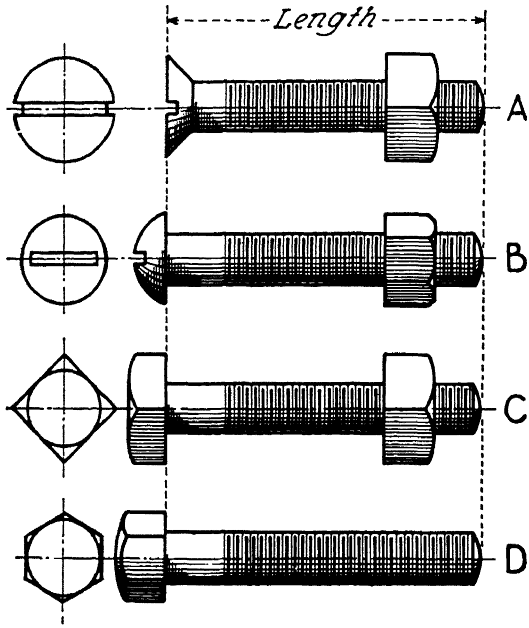

Fig. 197. A, flat-headed machine screw with square nut; B, round-headed machine screw with hexagon nut; C, machine bolt with square head and square nut; D, hexagon cap screw

(N.C.) are the ones generally used for average work. The fine threads (N.F.) are used extensively in automotive construction and electrical work.

The lengths of machine screws, cap screws, etc., are given in inches. A 1/4 by 1-in. machine screw is 1/4 in. in diameter and 1 in. long. Figure 197 shows lengths and types of typical screws. Machine screws are made of either brass or iron. Cap screws, setscrews, and machine bolts are usually made of iron only.

Taps for the foregoing screws are indicated by the gauge number or the diameter in inches followed by the number of threads per inch, as No. 6–32, No. 10–24, or 1/4″–20, 5/8″–11, etc.

Tools: Taps; tap wrench; drilling tools.

Materials: Material to be tapped; screws to be inserted; cutting oil.

METHOD:

1. Select the Tap

Hand taps are made in three styles; taper, plug, and bottoming (see Fig. 198). The plug type is the one most commonly used for general purposes. The taper style starts very easily when tapping a hole, but it must be turned farther in to make a full thread. The bottoming tap is useful to cut full threads to the bottom of a hole. Before using a bottoming tap it is best to tap as deep as possible with a taper or plug style.

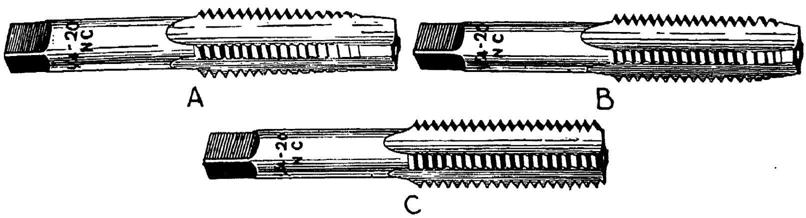

Fig. 198. Three common types of taps. A, taper; B, plug; C, bottoming

When tapping a hole, the mechanic should have in mind the size (diameter) and number of threads per inch of the screw he wants to insert. He then selects the tap to fit. If a hole is to be tapped for a ¼″–20 screw, then a ¼″–20 tap should be selected. The size of the tap and the number of the threads per inch are stamped on its shank (see Fig. 198).

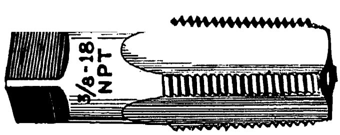

Fig. 199. A pipe tap. The size always is stamped on the shank

Figure 199 shows a typical pipe tap. This tap has tapered threads so that when the pipe joint is screwed up it does not leak. Figure 200 shows the common pipe-tap sizes and the corresponding tap-drill sizes. Since the size of pipe is indicated by the inside diameter, the taps are much larger than the size appears to indicate. For example,

Pipe-Tap Size	*Threads per Inch*	*Tap-Drill Size*
⅛″	27	R
¼″	18	7/16″
⅜″	18	37/64″
½″	14	23/32″
¾″	14	59/64″
1″	11½	1 5/32″
1¼″	11½	1½″
1½″	11½	1 47/64″
2″	11½	2 7/32″

Fig. 200. Table showing pipe-tap size, number of threads per inch, and the recommended tap-drill size

a ¼-in. pipe tap is about ½ in. in diameter, since it taps a hole to accommodate the outside diameter of the pipe.

2. Drill the Hole

See Figures 196 and 200 for the proper size drills to use. It is very essential that the hole be of the proper size. A hole too small may break the tap and a hole too large will not give a full thread. The hole is drilled perpendicular to the surface unless there are special reasons to do otherwise.

3. Clamp the Piece to be Tapped

The piece to be tapped must be held rigidly. It is very convenient if the drilled hole is exactly vertical or exactly horizontal. This will aid in guiding the tap into the hole.

4. Select the Tap Wrench

Special wrenches for tapping are called "tap wrenches" (see Fig. 201). For machine-screw taps ¼-in. and smaller, use a short-length wrench 5 to 7 in. long. With short wrenches, you are not likely to break the

Fig. 201. Adjustable tap wrench

taps. For larger taps, longer wrenches are used. Clamp the wrench tightly to the square end of the tap.

A T-handle style of tap wrench is shown in Figure 202. Such a wrench is useful for tapping in recessed places where the adjustable style wrench would not turn around.

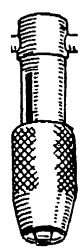

Fig. 202. A T-handled tap wrench with chuck

5. Tap the Hole

Figure 203 shows the tapping of a hole in a metal bar. Slight pressure is necessary to start the tap in the hole. Hold the tap in line with the hole, and press in slightly as you turn the wrench. The beginner can use a partner to advantage by having him sight the tap from a distance as it is turned into the hole. Do not force the tap. The tap is a fragile tool and may break. After the tap has caught, the pressure on it can be lessened and attention directed to keeping it straight as it is turned. At each revolu-

tion of the tap wrench, a slight backward turn will help to clean out the thread by breaking off the chips.

When tapping in steel, oil should be used on the tap. A special cutting compound or lard oil is recommended for this purpose. Common machine oil may be substituted if no cutting oil is available. (Machine oil is not

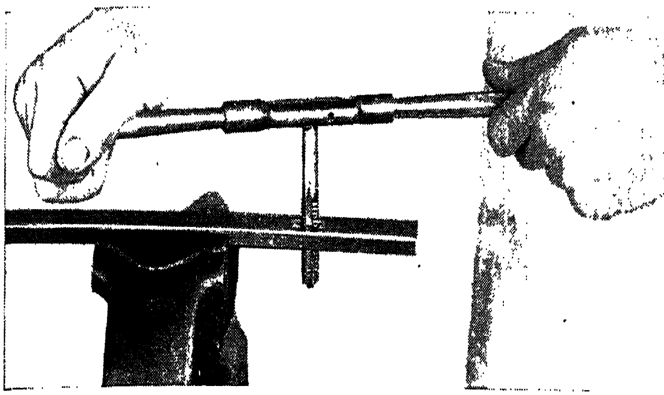

Fig. 203. Tapping a hole

recommended except in an emergency.) Holes in cast iron, brass, aluminum, or other soft materials can be tapped without oil.

STUDY QUESTIONS:

1. What are the three common tap styles? State use of each.
2. Where are the size and the thread number of each tap stamped?
3. In a 6–32 machine screw, to what does the 6 refer? the 32?
4. How is the size (diameter) of a large machine screw indicated?
5. Why is it necessary to drill holes of very accurate size for the different taps?
6. How is the tap started?
7. What might be the result if the tap is forced?
8. When would you use short tap wrenches? Why?
9. When should oil be used while tapping?
10. Why does a pipe tap have tapered threads?
11. Why is a ⅛-in. pipe tap so large in diameter?

Unit 28

TO THREAD A ROD

The common screw threads are the two series described in Unit 27 on tapping. They are the "National Coarse" (N.C.) and the "National Fine" (N.F.). Refer again to Figure 196 which gives the standard number of threads per inch for the coarse- and fine-thread series and the diameters for which they are recommended.[1]

Threads on pipes and rods are made by dies that cut a V-type groove as they are revolved about the work. Dies are usually made slightly adjustable with a small set-screw in the side of the die itself or in the collet that holds the die (see Figs. 207 and 208). Sometimes a set-screw in the stock controls the size of the opening of the die. The screw plate shown in Figure 206 includes dies and the corresponding sizes of taps. The modern dies are

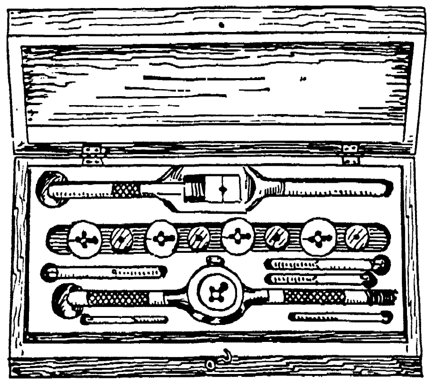

Fig. 206. A screw plate is a set of taps and dies

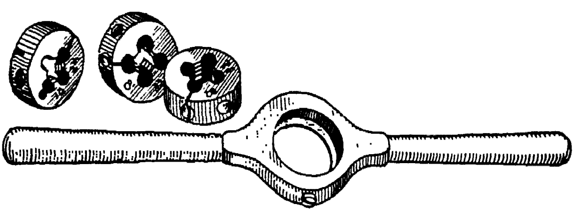

Fig. 207. Small dies and stock

held in a collet together with a guide. We refer to this assembly as die, collet, and guide. Note that the dies in Figure 207 do not have a guide. When speaking of a die, we refer only to the die itself.

[1]*Pitch* is the distance the rod advances in making one complete revolution or turn and should not be confused with the number of threads per inch. A pitch of 1/20 in. means that there are 20 threads to the inch.

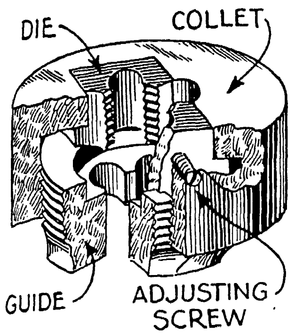

Fig. 208. Sectional view of a die, collet, and guide

When a thread is cut, the die always is used in a double-ended wrench called the "stock." Short stocks are used with small-sized dies and longer stocks for larger dies.

Tools: Vise; stocks and dies.

Materials: Round rod; lard oil; or cutting compound.

METHOD:

1. Prepare the Rod

Cut the bolt or rod to the proper length. Remove any burrs with a file or by grinding. If the end is beveled slightly it will aid in the starting of the die (see Fig. 209).

2. Select the Proper Die

If the diameter of the rod is not known, measure it with a caliper rule or screw gauge. This is to determine the size (diameter) of the die to use. The first number stamped on the die refers to its diameter. For large sizes these diameters are given in fractions of an inch. Diameters smaller than ¼ in. usually are given in screw-gauge numbers (see Figs. 207 and 210).

Fig. 209. Bevel the end of the rod for easy starting of the die

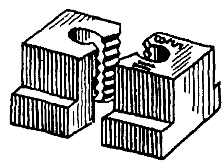

Fig. 210. Adjustable die parts. Note the ⅝–11 stamped on the die

If the number of threads per inch is not known, it is necessary to measure the thread in the hole into which the screw is to fit. Figure 211 shows a screw-pitch gauge for measuring thread pitch. Find the blade of the screw-pitch gauge that fits perfectly in the desired thread. The corresponding number of threads per inch is stamped on each blade of the gauge. If the hole is too small to accommodate the gauge, test with a screw that will fit properly and then measure the pitch of the screw. The second number on the die refers to the number of threads per inch.

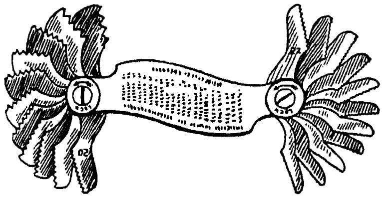

Fig. 211. Screw-pitch gauge

If a screw-pitch gauge is not available, the thread in the nut or hole into which the rod is to fasten can be tested with various taps. A tap of the same size will screw easily but snugly into the hole. The size and pitch of the thread is then read from the markings on the tap that fits. Select a die of the same size and number of threads.

3. Place the Die in the Die Stock

Dies are always used in a die stock. Place the selected die in the stock and fasten it in place. It is usually held securely with a setscrew or with one handle of the stock.

4. Clamp the Work

The vise is useful for holding work to be threaded. Clamp the work in a convenient position so that the die stock can be turned completely

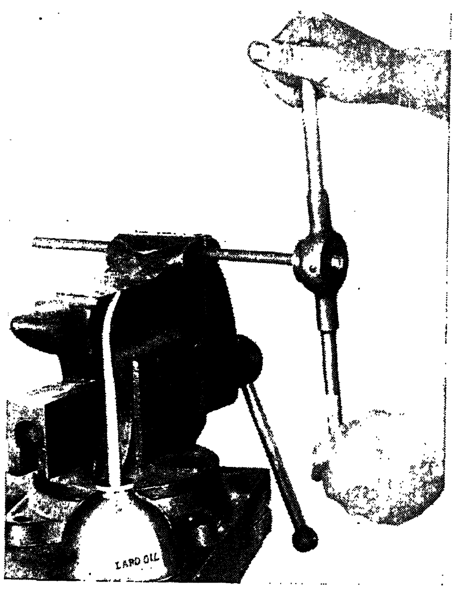

Fig. 212. Cutting threads on a rod

around without interference. A horizontal or a vertical position of the work usually is used by the mechanic (see Fig. 212).

5. Cut the Thread

Use lard oil or some cutting compound on iron or steel. Several oilings during cutting usually are necessary. Cutting oil is not necessary on copper, brass, or aluminum. For right-handed threads turn the right-hand

die clockwise. Apply the die, and press it on as you turn. Try to hold the stock and die at right angles to the work. Make a special effort to do this if the die contains no guide. When the die has caught, the pressure can be omitted as you turn. Note if a clean thread is being cut. If cuttings tend to clog the die, a ragged or torn thread may result and backing up will clean out the chips. Cut the thread to the desired length, and then back off the die.

Left-hand dies are made to cut left-hand threads. To cut a left-hand thread turn the left-hand die counter-clockwise.

6. Test the Thread

A nut of the same size and thread should turn on freely with the hands. If too tight, recut the thread after slight adjustment of the adjusting screw in the die. Turn the adjusting screw so that the hole in the die is smaller to cut a smaller thread. Repeat until the desired fit is obtained.

If the thread is cut too loose, it cannot be remedied by recutting, since it is already too small. It is therefore necessary to cut a new rod. Open up the die with a slight turn of the adjusting screw, and cut a new thread. Test as before.

STUDY QUESTIONS:

1. What tool is used to cut an external thread?
2. What is a screw plate?
3. What is a stock?
4. What is meant by N.C.? N.F.?
5. How can you tell the size of a die?
6. What is meant by a No. 12–24 thread? a ⅝–11 thread?
7. Why bevel the end of a rod before threading?
8. When do you lubricate for cutting a thread?
9. How can you test a thread?
10. Can a thread that is too tight be remedied? How?

Unit 29

TO CUT AND THREAD PIPE

When the metalworker finds it necessary to do some piping he cuts the desired lengths from a long section of pipe and then threads the ends with a stock and die. The common stocks have removable dies so that different sizes of pipe may be threaded with the same stock. Dies are always plainly stamped for the size they cut and whether right (R) or left (L) thread. Adjustable dies also are stamped with a proper align-

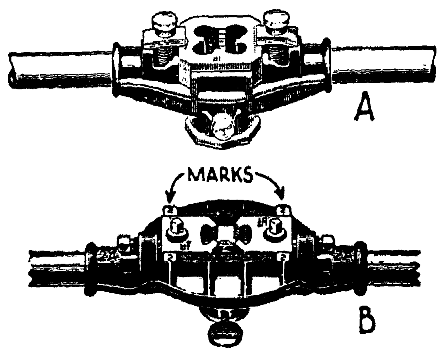

Fig. 215. Pipe-threading stocks and dies. A, stock with one-piece die; B, stock with two-piece dies or adjustable dies

ment mark (see Fig. 215). There are adjustable stocks that contain several different sizes of cutters in the same head. With a stock and die once adjusted, it is an easy matter to cut a thread by hand.

The electrician does a great deal of electrical installation in conduit. Threads are cut on conduit in the same manner as on water pipe or gas pipe.

The size of pipe is stated in inches and is the inside diameter. The sizes commonly used in project work are ⅛, ¼, ⅜, and ½ in. The actual inside diameters are slightly larger than these dimensions. The common electrical socket is usually attached by a ⅛-in. pipe. Many electrical projects will call for the cutting and threading of pipe from ⅛ to ½ in. in diameter.

Short pieces of pipe with both ends threaded are called "nipples." They are available in short lengths up to 6 in. The electrician often finds

use for short nipples made of brass in 1/8 and 1/4 in. pipe sizes. Pieces of pipe threaded the entire length are said to have a running thread.

Tools: Vise (pipe or combination); pipe cutter or hack saw; stock and die; brace; and pipe reamer.

Material: Pipe to be cut and threaded.

METHOD:

1. Lay Off for the Cut

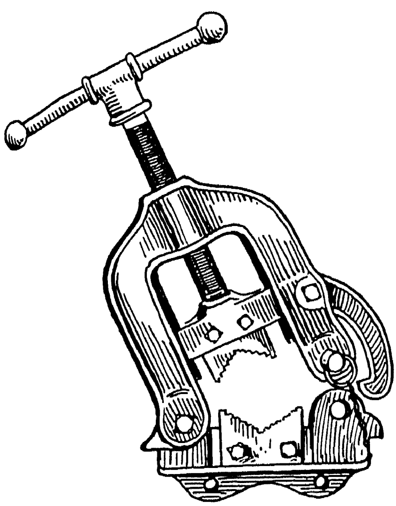

Fig. 216. A regular pipe vise

When the length of the pipe is determined, lay off accurately and mark with a piece of chalk, scriber, or file.

2. Cut Off the Pipe

A pipe cutter is commonly used for cutting pipe. Clamp the pipe tightly in the jaws of a combination vise or in a regular pipe vise. Figure 216 shows a regular pipe vise, and Figure 217 shows a combination vise in use. The pipe jaws in both vises are similar.

Slip the cutter onto the pipe, and close the cutting wheel into the

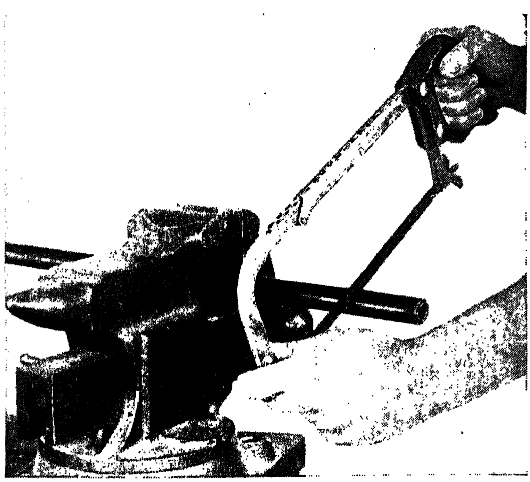

Fig. 217. Cutting pipe with a hack saw

mark (see Fig. 218). Rotate the cutter one revolution, checking to see if the cutting wheel tracks are in the same kerf. Turn the handle of the cutter which forces the cutting wheel deeper into the pipe, and rotate again. For every rotation tighten the wheel until the pipe is cut through.

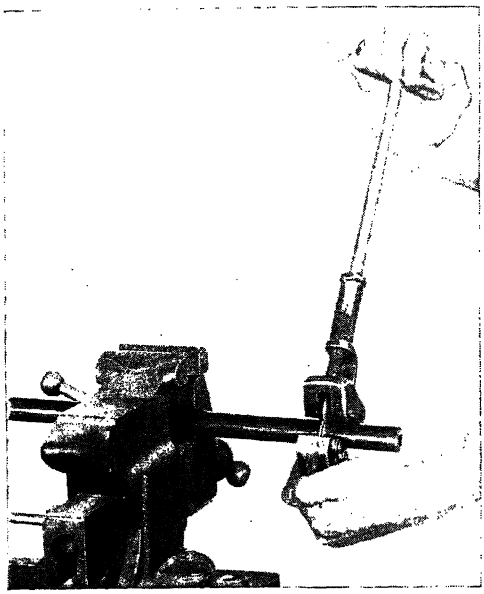

Fig. 218. Using a pipe cutter

The electrician and the mechanic often use the hack saw for pipe cutting. This method leaves a smaller amount of burr on the inside of the pipe. Clamp the pipe as above, and saw with a fine-toothed blade (see Fig. 217).

3. Ream the Pipe

A newly cut pipe is likely to be burred on the inside. Such a burr should be removed with a reamer and brace (see Fig. 219).

4. Cut the Thread (see Fig. 220)

Follow any special instructions accompanying the stock and die.

Always oil iron pipe where the thread is to be cut, with some cutting compound such as good lard oil or black sulphur-base thread-cutting oil. It is also advisable to put oil on the dies several times while cutting the thread.

Check the stock and die for the proper die and collar. Marks on the stock and adjustable dies when in alignment give the proper adjustment

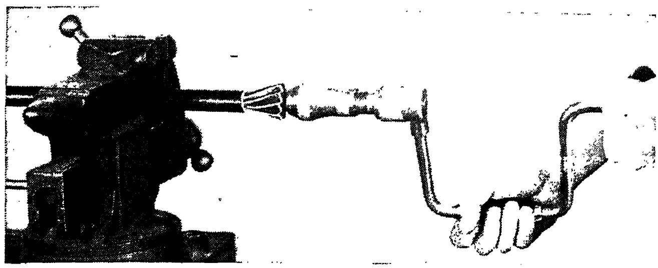

Fig. 219. Removing the burr from inside of pipe

and cut a standard thread. The guiding collar just slips over the pipe to cut a straight thread on the pipe. Slip the stock over the pipe, and turn it in a clockwise direction for a right-handed (R) thread. Push hard on the stock as you turn to start the thread. After the thread has caught, it is only necessary to turn the stock for it is now self-feeding. (Several oilings during the cutting are necessary.) Cut until the thread shows through the dies. The stock is removed from the pipe by turning it backwards.

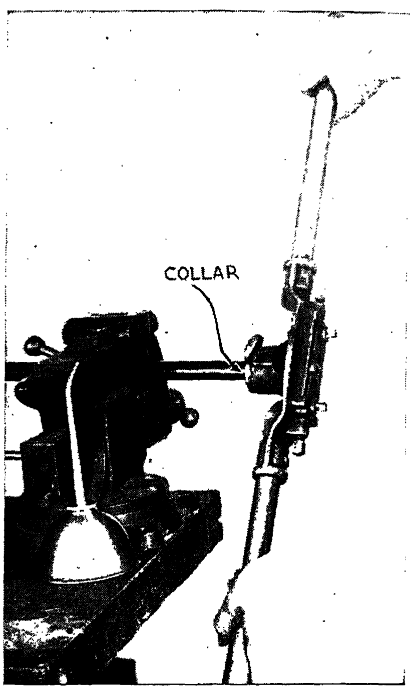

Fig. 220. Cutting a thread

A thread is easily tested by a standard pipe fitting of the same size. Such a fitting should only turn on several turns by hand. Additional turns are made with a pipe wrench to make the joint leakproof.

To cut a tight or a loose thread, readjust the adjustable dies in the stock accordingly. Move the dies toward each other for a *loose* thread and away from each other for a *tight* thread. The solid or one-piece die is not adjustable and cuts only one size of thread.

If the easy receding die type of tool is used, start the tool for cutting standard pipe threads according to instructions accompanying the tool; then accurately center the tool on the pipe, and tighten the thumb or

setscrews evenly all around. These tools are equipped with a lead screw which draws the dies onto the pipe and it is not necessary to push for starting the thread. Merely rotate the tool by means of the two handles. If the ratchet type handles are used they may be operated in the most convenient manner.

Keep the die clean and free from iron chips or shavings. A clean, sharp tool will produce a perfectly cut thread.

STUDY QUESTIONS:

1. What tool is used to thread pipe?
2. Why does the electrician cut and thread pipe?
3. How is the size of a pipe measured?
4. What is a nipple? a running thread?
5. What tool is usually used to cut pipe?
6. What tool does the electrician often use to cut pipe? Why?
7. Why is a pipe reamed?
8. What is an R thread? an L thread?
9. State some rules for cutting a thread.

Unit 30

METAL FITTINGS

Plumbing and electrical fittings are separate finished parts often used in the construction of metal projects. Plumbing fittings are made in either cast iron or malleable iron. Malleable fittings are generally used since they do not break readily and they are not so large and bulky. Many of the common plumbing fittings are shown in Figure 223, all of which are made of malleable iron.

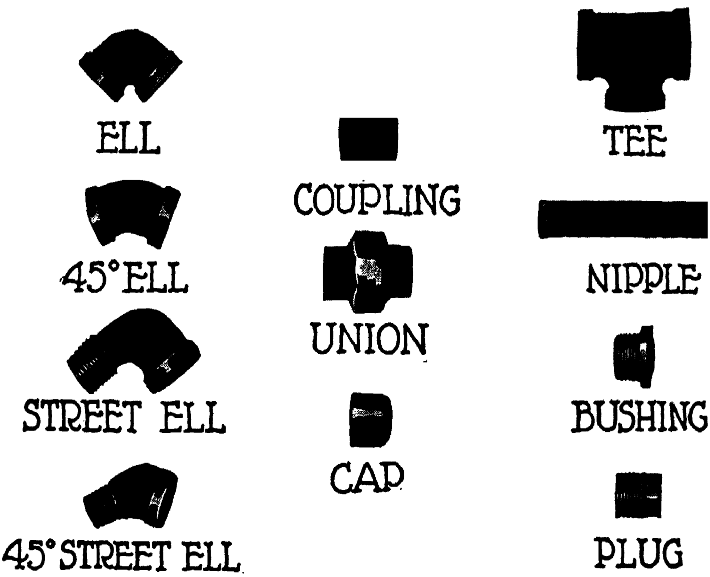

Fig. 223. Common pipe fittings

The plumber, the electrician, and the machinist must know how to assemble the common pipes and fittings. Most fittings fasten together with a screw thread. Plumbing fittings are threaded or tapped with the regular pipe threads as described in Unit 29. Most electrical fittings also use the pipe thread, the smallest being ⅛-in. pipe. Threads are either on the outside or the inside of a fitting.

Plumbing fittings usually are assembled by means of a pipe wrench. This wrench will take hold on a round pipe or fitting at any place. To use this wrench, adjust the jaws so they will just slip over the pipe or

fitting, and always turn toward the open side of the jaw. Figure 224 shows a pipe wrench used to tighten a coupling on a piece of pipe.

Brief descriptions of the common plumbing fittings follow:

Nipples are short pieces of pipe threaded from both ends and are used to connect fittings. They are made in long and short lengths for all sizes of pipe. A short nipple with the threads of both ends very close

Fig. 224. A pipe wrench used to turn on a coupling

together is called a "close nipple." Nipples are sometimes made with a running thread and are used in conduit work. Running thread is not used for gas or water connection since it does not make a leakproof joint.

Elbows are made in either 45 or 90 deg., and are used for changing the direction of any pipe line. Note the different types of elbows (ells) in Figure 223.

Tees are used where a tap is to be taken from a through line.

Couplings are used to join lengths of pipe or fittings with outside threads.

Unions are used to connect two separate pipe assemblies. They allow the connection to be made without turning any of the parts being joined. Only the collar of the union turns to make the connection. The joint can be disconnected with the same ease without removing a lot of fittings. The common union needs a rubber or composition gasket to make it leakproof. A railroad union has a ground brass seat and requires no gasket.

Bushings are used when different sized pipes or fittings are to be joined together.

Caps and Plugs are used for closing any unused openings. Outside threads are capped and inside threads are plugged.

Fig. 225. Cord outlet

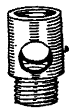

Fig. 226. Brass hickey

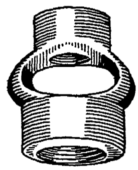

Fig. 227. Malleable-iron hickey

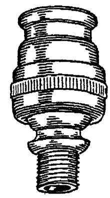

Fig. 228. Ball-and-socket joint

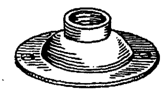

Fig. 229. Brass wall plate; inside thread

The following fittings and parts are commonly used in electrical work for lamp and fixture assemblies.

Cord Outlet. Figure 225 shows a cord outlet which is useful for locking a socket to a lamp bracket and allows a cord to enter through the outlet to the socket. These outlets usually are made of brass and have a ⅛-in. pipe, inside thread.

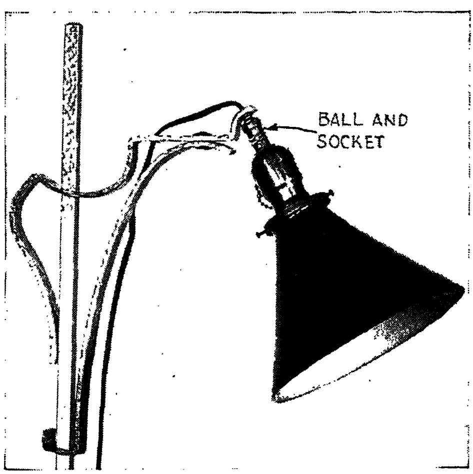

Fig. 230. Ball-and-socket joint in use

Hickeys. Figure 226 shows a typical open-armed hickey made of brass. The hickey shown in Figure 227 is made of malleable iron. The openings in the side of the hickey permit the entrance of wires to the electrical outlet. Hickeys are used in fixture outlet boxes and for portable lamps.

Ball-and-Socket Joints. Figure 228 shows a ball-and-socket joint. It is

used on portable lamps to allow adjustment of the lamp socket to various positions or angles, and is shown in use on the lamp in Figure 230.

Half Shells and Cones. Figure 231 shows a half shell and a cone used in constructing a lamp body, and an assembled lamp is shown in Figure 232. This lamp body is an imitation of the old oil-lamp reservoir.

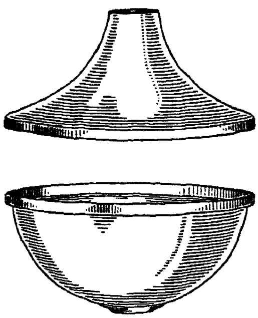

Fig. 231. Parts for lamp body. See Fig. 232 for assembly. Upper: brass cone; lower: brass half shell

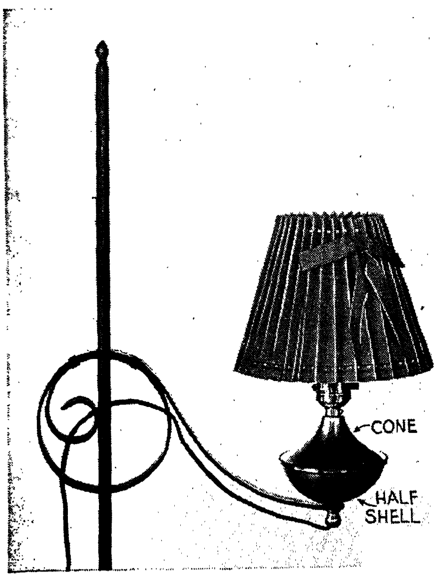

Fig. 232. Lamp bowl made from cone and half shell

Half shells and cones can be purchased from lamp-fixture manufacturers. When ordering, it is best to indicate that these are to fit together.

Wall Plates. Figure 229 shows the type of wall plate used for connecting a lamp socket to a wood lamp post. Plates are furnished with outside or inside thread.

STUDY QUESTIONS:

1. Why are malleable plumbing fittings generally used?
2. What type of thread is used in plumbing fittings?
3. What kind of wrench is adaptable to use on pipe and fittings?
4. What is a nipple? an elbow?
5. What is the use of a union?
6. State uses of tees, couplings, bushings, caps, and plugs.
7. What is a cord outlet?
8. What is the advantage of a ball-and-socket joint?
9. What parts make up the lamp bowl shown in Figure 232?

Unit 31

TO MAKE AND POUR A MOLD

Foundry work consists of making molds with sand and then pouring in molten metal to make castings. The making of molds and castings is an important branch of the great metalworking industry. One needs only to look around to see the general use of molding, for many small as well as large objects in the home, shop, and industry are made from castings. The average person is not so familiar with foundry work since such shops usually are located in the outskirts of the cities.

In order to make a mold and cast an object, a pattern of the object to be cast is necessary. Patternmaking is a big industry in the woodworking field, since patterns usually are made of wood. The patternmaker shapes a pattern from wood and the molder uses the pattern to make a mold in sand. The mold is then poured full of molten metal, and a casting like the pattern results.

The following description for making a mold is given so that the beginner will have first-hand information on how molding is done. Even

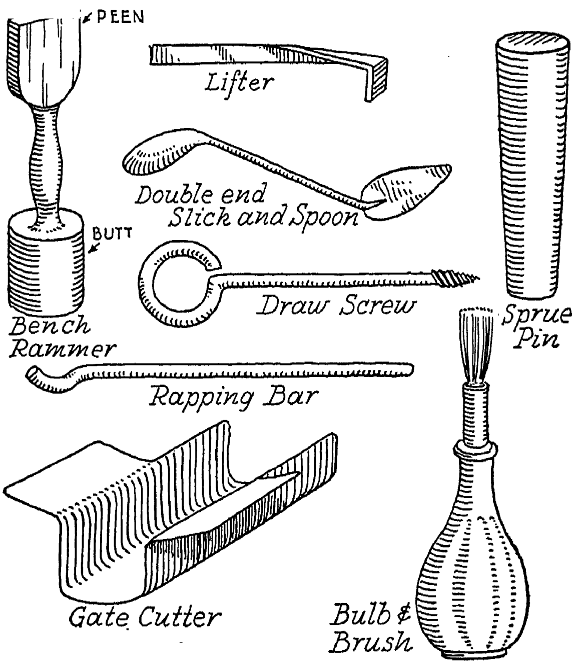

Fig. 235. Useful molding tools. Many of these tools can be made in the shop

in small shops with simple equipment, small castings can be made from the softer metals, since these metals can be melted in the average shop. The processes encountered are duplicates of the manipulations carried on in the regular foundry. Any boy would show extreme interest in making a mold, pouring it with molten metal, and finally viewing his first casting.

Tools (see Fig. 235): Shovel or trowel; screen; draw screw; rapping bar; bellows; bulb and brush; rammer; gate cutter; sprue pin; slicks and lifters; flask; moldboard; bottom boards; pattern; furnace; melting pot; and ladle.

Materials: Molding sand; parting sand; water; and metal.

METHOD:

1. Temper the Sand

Tempering the sand means to add moisture so it will pack. Sprinkle the sand uniformly with water, and thoroughly mix with a shovel or trowel. Test for the proper moisture content as follows: Make a lump of sand by squeezing a handful together in the hand. Break the lump into parts with the fingers, and if the edges at the breaks are firm and sharp, the sand is ready for use.

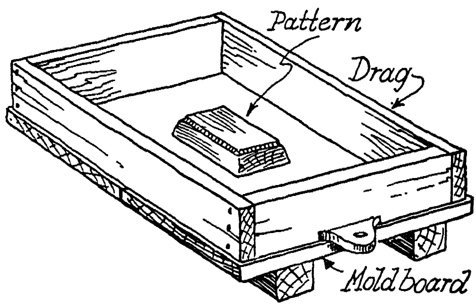

Fig. 236. Moldboard, pattern, and drag in position ready for sand

2. Place the Pattern on the Moldboard

Place the pattern centrally on the moldboard with the largest dimensions down (see Fig. 236). A pattern must have draft (be tapered) so it can be withdrawn from the sand (see note below for special patterns).*

*NOTE: If a split pattern is to be used, place the half with the pinholes on the moldboard with the holes down. The other half of the pattern, which contains the dowel pins, will not be used until Step 7. See Figure 241 showing a split pattern of a cylinder. The object of splitting a pattern is to make molding easier.

If only a solid pattern (of an object like a cylinder) is available, it may be placed as shown in Figure 242. In this case, however, when the drag is turned over, sand will have to be removed to the center line of the cylinder, in order to allow withdrawal from the mold.

3. Set Up the Drag

The drag is the half of the flask that is used for the bottom half of the mold. Select either half of the flask for this purpose. In either case, place the drag down on the moldboard and over the pattern with the pins or the sockets down as shown in Figure 236.

4. Add and Ram the Sand

Riddle (screen) the sand into the drag to cover the pattern about 1 in. Pack the sand around the edges of the pattern, using the fingers to press it firmly in place. Take special care to pack the sand next to the moldboard and pattern. Then fill the drag heaping full of unriddled sand and start ramming. Peen-ram around the sides of the drag first and then over the entire surface. Fill the drag heaping full of sand again, and use the butt-ram to pack the sand down over the entire surface. Finally, with a straightedge, strike off the excess sand to make it level with the edges of the drag.

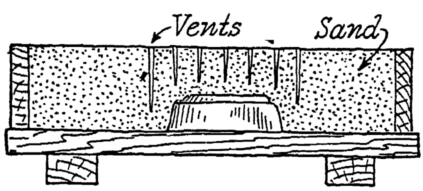

Fig. 237. Drag rammed and vented

5. Vent the Mold

Venting allows the gases generated by hot metal to escape from the mold so they cannot cause damage. For making small castings of soft metal, venting is unnecessary. Regular venting for large castings is accomplished as follows: Use a wire 1/16 in. in diameter, and punch holes in the sand directly above the pattern. A knitting needle also serves well for this purpose. Space the vent holes about 1 in. apart, and make them reach to within about ½ in. of the pattern (see Fig. 237).

6. Add the Bottom Board and Turn Over the Drag

Throw a thin layer of fine, loose sand over the level sand surface of the drag. Lay on the bottom board and rub it back and forth so that it rests solidly on the drag.

Hold the drag firmly between the moldboard and the bottom board, and turn the drag over so that the bottom board will rest on the bench. Try to keep the boards from slipping as the drag is turned over. Remove the moldboard, and slick down any rough sand surface with a trowel.

A smooth surface will make a good parting. Blow off any loose sand with the bellows. Dust the pattern and the surface of the sand with a layer of parting sand. This is easily dusted on through a cotton bag. Blow off all excess parting sand from the pattern.*

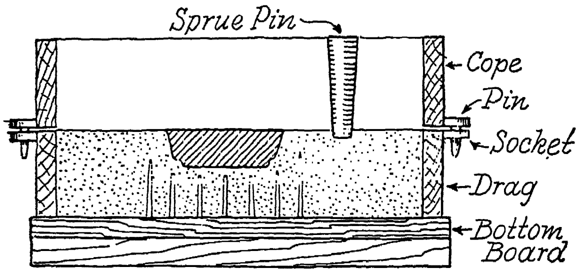

Fig. 238. Drag turned over on bottom board, sprue pin located, cope in place and ready for molding sand

7. Set the Cope (see Fig. 238)

Place the cope on the drag, seating the pins firmly in the sockets. Test to see if the cope slides up and down readily. Never oil the pins, but use wax to aid sliding.

8. Set the Sprue Pin

The sprue pin, which should be slightly longer than the depth of the cope, makes the hole in the sand through which the molten metal is poured. Set the pin into the molding sand of the drag about 1/4 in. to hold it upright, and at least 1 in. away from the pattern (see Fig. 238).

9. Ram the Cope

Fill and ram the cope just as you did the drag in Step 4. Vent the cope (if necessary) as described in Step 5.

10. Remove the Sprue Pin

Twist or jar the sprue pin, and pull it carefully from the sand. With the forefinger, cut the sprue hole to a funnel shape as shown in Figure 239. Pack the sand firmly around the sprue hole.

11. Lift the Cope

Stand so you can lift the cope straight up. Take hold of the guides

*NOTE: If a solid pattern like that of a cylinder was used, remove the sand to the central line of the cylinder. This will allow the pattern to be removed (see Fig. 242). Slick down the disturbed sand surface and add parting sand as directed in the foregoing. If a split pattern was used, place the other half of the pattern in position at this time.

(pins or sockets) or handles, and carefully lift the cope straight up and free from the drag. Set the cope on its side, out of the way, so it will not be disturbed or upset.

12. Draw the Pattern

With a rubber-bulb swabber, or other device, carefully wet the sand just next to the pattern, being careful not to get it too wet. Wetting will help to hold the sand firmly in place when the pattern is drawn. Turn

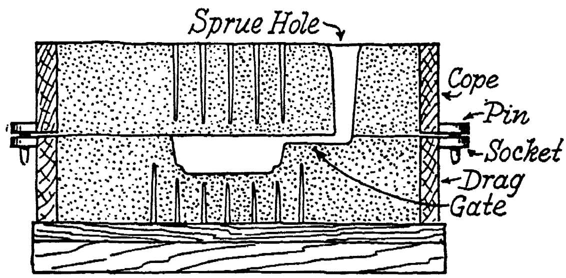

Fig. 239. Showing location of gate between sprue hole and pattern

a draw screw into the pattern. Now, gently rap the draw screw from all sides in order to loosen the pattern in the sand, and give a slight clearance. Tap gently with one hand, and lift the pattern straight up, at the same time trying to leave the sand undisturbed. If the sand is cracked or broken while lifting, allow the pattern to settle back into place and repair cracks or breaks by slicking down the sand around the pattern. Finally, lift out the pattern and remove any loose sand.

13. Cut the Gate (see Fig. 239)

The gate is a channel, cut in the sand, from the pattern to the sprue hole. This channel allows the molten metal to run into the mold. With a gate cutter or other tool, cut the gate about ¼ in. deep and ¾ in. wide, making it slightly deeper at the sprue hole. Remove any loose sand.

14. Close the Mold

See that the sprue hole is entirely open and that the sand surfaces in both the cope and the drag are in good condition. Grasp the cope, as before, at the guides, and turn it right side up to allow any loose sand to fall away and not fall on the drag. Now place it on the drag, carefully guiding the sockets and pins together. If the mold is not to be poured immediately, cover the sprue hole to keep out loose sand or dirt.

15. Prepare the Mold for Pouring

If the mold is to remain in the original flask for pouring, clamps are useful to hold the parts together on the bottom board (see Fig. 240).

If a snap flask was used, open the snap fastenings and remove it. Now

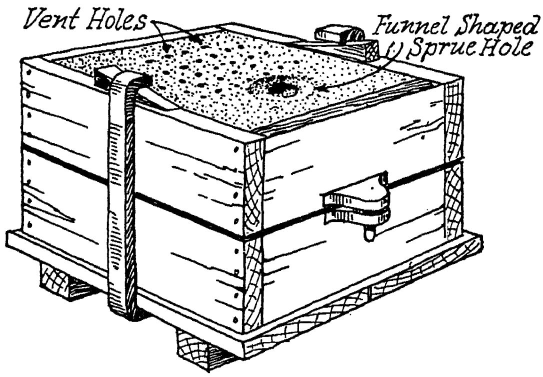

Fig. 240. Cope and drag clamped and ready for pouring

place a slip jacket around the mold and fill between the mold and jacket with molding sand. A weight placed on top of the mold will keep the molten metal from lifting the sand in the cope.

16. Pour the Mold

For beginners, the soft metals may be used for pouring. They can be melted in a forge, a gas furnace, or with a gasoline torch.

Lead is easily melted and it pours a mold readily. Lead, however, will not give a sharp casting since it shrinks greatly at the time of setting.

Type metal makes splendid castings, since it expands to give sharp impressions.

Aluminum offers opportunity for an easy melting metal. It alloys readily with lead, tin, antimony, and zinc. An alloy of 95 parts aluminum and 5 parts zinc is easily melted and can be used to make small castings.

If *iron* is to be poured into the mold, see some text covering the use of the cupola.

Figure 243 shows a metal mold and several castings made from this type of mold. Metallic molds offer opportunity to pour castings without making molds of sand. Lead usually is used to pour such molds, to make toys, fishing sinkers, and many other small castings.

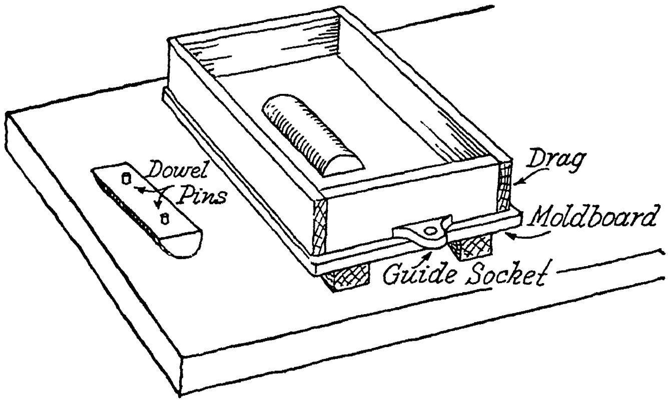

Fig. 241. Drag set up using a split pattern

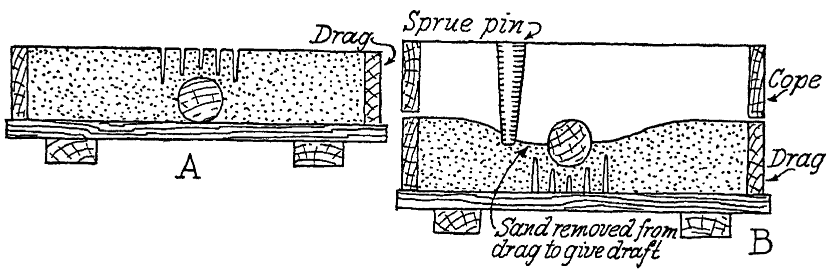

Fig. 242. Method for molding with a solid pattern to get draft

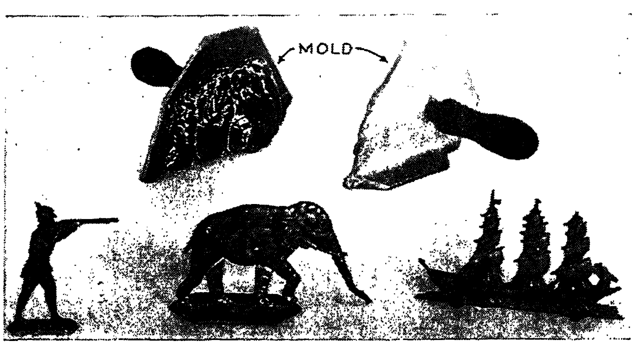

Fig. 243. Metallic molds are available for casting many small articles

STUDY QUESTIONS:

1. What is a mold? a casting?
2. What is the use of a pattern?
3. Of what are patterns usually made?
4. Name some soft metals that are easily melted.
5. How and why is sand tempered?
6. What is meant by draft of a pattern?
7. Name the two parts of a flask.
8. What is the use of parting sand? a sprue pin? the gate?
9. What is the objection to using lead to make castings?
10. State an advantage of type metal for making castings.

Unit 32

THE METALS

Metals make up a group of materials commonly used for construction purposes. An outstanding property of metals is that all possess a luster. This means that if the surface is clean and polished it reflects light like a mirror. Other properties common to metals are hardness, malleability, and ductility. Malleability and ductility refer to the properties allowing metal to be hammered, rolled, or drawn out into sheets or wire without breaking. Metals also conduct heat and electricity well.

Some of the metals corrode or rust easily. This means that a coating forms on the surface of the metal. This coating is usually the result of air, or other constituents of the air, attacking the outer layer of the metal and changing it. This attack is called "corrosion." "Rusting" is a special term applied to corroding iron. It is quite a problem to prevent the corrosion of iron and other metals.

An alloy is a mixture of a metal with other substances — usually one or more metals. Recent experiments have discovered many new and useful alloys. Some of the outstanding alloys are steel, brass, bronze, German silver, and duralumin.

A brief description of some of the common metals and alloys is given to inform the beginner of the use and characteristics of these metals and alloys. It is hoped that those interested in metalwork will be privileged to work with most of the metals or alloys described in the following.

1. Iron and Steel

Iron is the most important and widely used metal. A great many things used in daily life have either direct or indirect contact with iron. Pure iron, however, is seldom used. Wrought iron is one of the purest forms manufactured, but its use is rapidly giving way to mild steel.

Steel, which is an alloy of iron and carbon, is the common form in which iron is so universally used. Mild steel contains very little carbon, and tool steel has in the region of 8/10 of 1 per cent of carbon. Cast iron has about 3 to 4 per cent of carbon content.

Mild steel is the form of iron most used in the average shop, to construct projects and make repair parts (see Fig. 246). It is rather

soft, tough, and very malleable and ductile. It can be formed and shaped readily, either cold or hot. Of course, heating aids in bending and shaping it. Mild steel cannot be hardened, so it is not used to make edge tools.

The commercial forms of mild steel available are wire, bars, rods, and sheets. There is a great demand and use for bar metal called "flats" or "strap iron." This is used extensively for making small projects, and it can be worked cold. Bars are also made in various shapes as angle iron and channel iron, and in rods, as round, square, hexagon, and octagon. Mild-steel wire is used in the manufacture of thousands of articles of commercial value. Among these articles are screws, nails, bolts, rivets, and numerous other fastenings (see Fig. 247).

Fig. 246. Project made from mild steel bars

Tool steel, as its name indicates, is used to make tools. It has the proper carbon content so it can be made very hard. Screw drivers, cold chisels, punches, plain irons, hammers, saws, and files are all made of tool steel. The process of hardening and working tool steel will be discussed in more advanced work.

Cast iron, as a raw material, is not likely to be used by the beginner. It is also an alloy of iron and carbon but contains a higher content of carbon than steel. It is used mainly by the foundryman to make castings. Cast iron, while very strong, is very brittle and will break if hit hard blows. Many small objects in daily use are made from cast iron.

One of the great objections to iron and its alloys is the tendency to rust. In the presence of moisture and acids, rusting is very rapid. To protect iron from rusting, it is coated with some material to keep air and moisture away. Paint is often resorted to as a temporary protection. Metals that do not rust readily are used to make more permanent coatings on iron and steel. Some of the metals used for this coating are tin, zinc, copper, nickel, and chromium.

2. Copper

Copper is a reddish metal. It is soft and very malleable and ductile. Unlike iron, it resists rusting by forming a coating of oxide which sticks

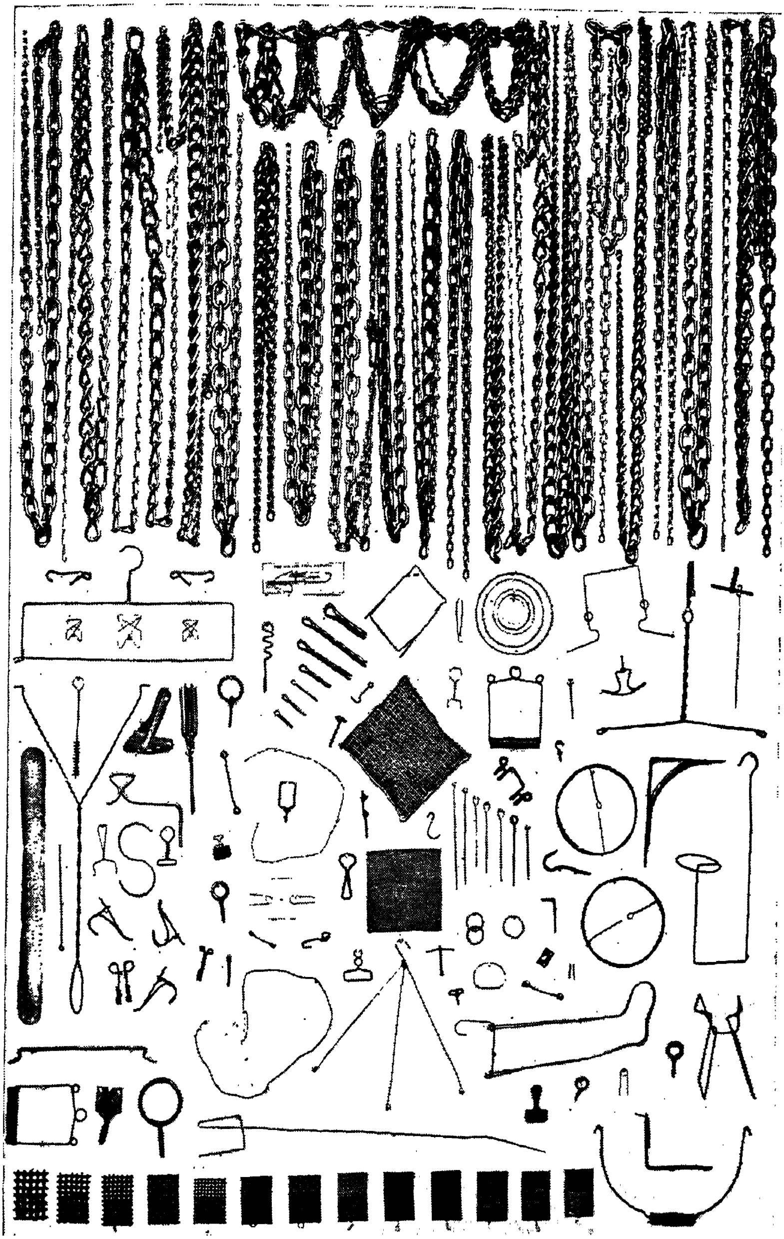

Fig. 247. Some varieties of articles made from round steel wire

tightly to the surface as a protective covering. It is a good conductor of heat and electricity. Copper is obtainable in wire, bars, rods, tubing, and sheets. The most widely used form for construction purposes is the sheet. Sheets are furnished in various thicknesses and sizes, in unpolished, polished, and with one side tinned. Copper is much more expensive than iron, but its useful properties make it very desirable.

Copper is used to make electrical wires and conductors, soldering coppers, rivets and burrs, pipes and tubing, vessels to hold liquids, and articles exposed to the weather (see Fig. 248). Copper makes splendid

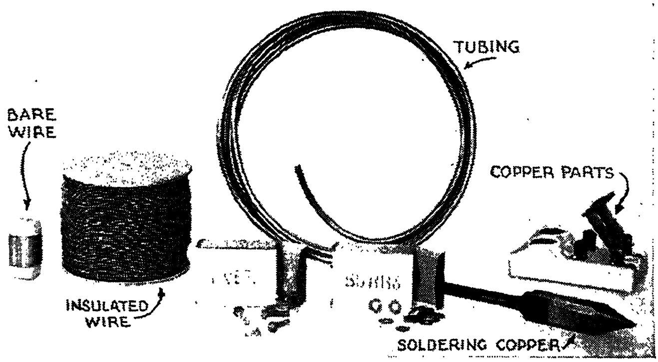

Fig. 248. Some uses of copper

roofing, and copper nails are used in the best boat construction. Iron wire is often coated with copper.

Copper is used extensively in the making of alloys. It forms a part of German silver, bronze, and brass. Brass, which is used extensively for cast and turned parts, is an alloy of copper and zinc. The common brasses have from 60 to 70 per cent copper. Brass is available in wire, rod, sheet, pipe, and tubing. You will observe articles daily that are made from brass.

3. Lead

Lead is one of the softest metals. It is so soft and pliable that small projects of thin sheet lead can be shaped with the hands (see Fig. 249). Lead also has a low melting point, and it can be readily used for casting small articles. It is used extensively by the metalworker as a backplate for punching (see Fig. 250). Lead is very heavy and protects itself from rusting like copper. Many acids do not attack lead readily. Lead sheet is the form generally used by the mechanic for construction purposes. It is also furnished in small and large blocks, called "pigs," for melting.

Lead is used for roofing, water pipe, and coverings for electrical cables. Very thin sheets make lead foil. It is cast to make many small toys and

is used to make bullets and storage-battery plates. It is also used to line some acid tanks. Lead is alloyed with tin to make soft solder, with antimony and tin to make type metal, and with antimony, tin, and copper to make babbitt.

Lead forms the basis for white-lead and red-lead paints.

Fig. 249. Shaping lead trays with the hands

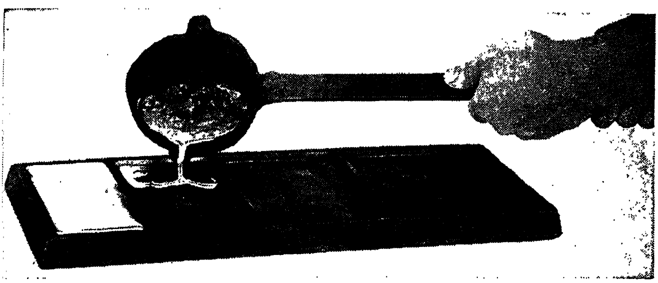

Fig. 250. Pouring lead plates for use in metalwork

4. Aluminum

Aluminum is a metal known for its light weight. It is soft, malleable, ductile, and easily worked with hand tools. It is quite noncorrosive and is a good conductor of heat and electricity. Aluminum is available in the forms of wire, rods, and sheets. Many uses are found for aluminum in sheet form. Aluminum is rather difficult to solder and for that reason has not been used where soldered joints are necessary (see Unit 6).

Many cooking utensils are made from sheet aluminum (see Fig. 251). Many other containers are made from cast aluminum. Aluminum is also used extensively as an electrical conductor. Many aluminum alloys are now in use. The elements alloyed with it are chiefly copper, magnesium, zinc, nickel, and iron. Prominent alloys are aluminum bronze and duralumin. Some of these alloys can be hardened or softened by heat

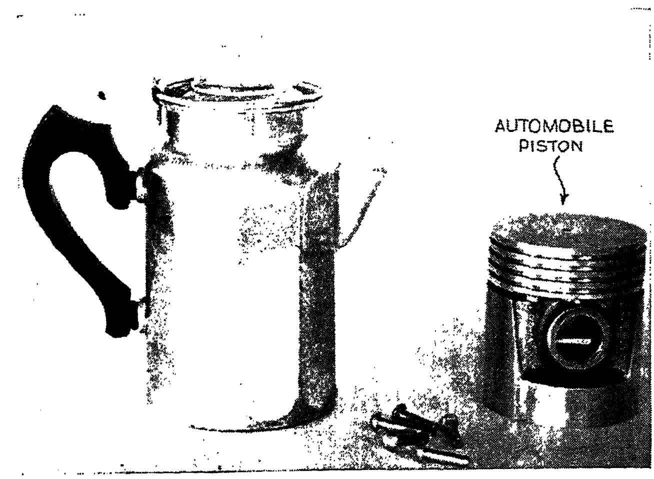

Fig. 251. Cooking utensils and automobile parts often are made of aluminum

treatment. Airplane and automobile construction consumes the largest percentage of aluminum. (See the aluminum piston in Fig. 251.)

5. Tin

Tin is a metal, but the so-called "tin can" contains very little tin. The metal tin, which is noncorrosive and acid resisting, is silvery white, and can be cut and hammered easily. Tin is not found in great abundance, and is rather expensive for that reason.

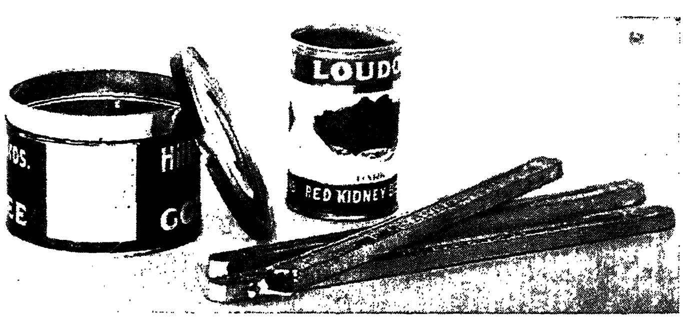

Fig. 252. Tin cans and soft solder are partly made of tin

The greatest use for tin is for protective coatings on other metals. "Tin plate" is sheet iron with a covering of tin (see Fig. 252). Copper and brass are often similarly coated. Tin is very useful in the formation of alloys. The common soft solder is 50 per cent tin and 50 per cent lead.

6. Zinc

Zinc is a metal that was known and used by the ancients. It forms a coating on its surface which protects the inner metal. Zinc is soft and easily worked with tools. It is obtained and used mainly in the sheet form for various purposes.

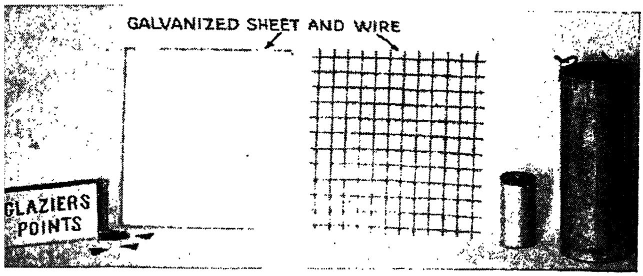

Fig. 253. Common uses of zinc

Zinc is used for roofing parts, glazier points, and dry-cell containers. It is a favorite covering for iron to protect it against rusting. This is known as "galvanized" iron (see Fig. 253).

Brass contains a high percentage of zinc. The properties of brass were described under copper.

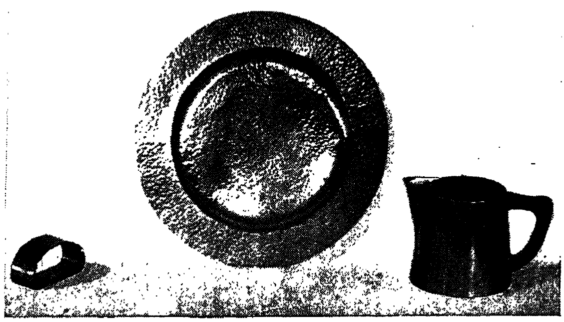

Fig. 254. Articles made from pewter

7. Pewter[1]

Pewter is an alloy that lends itself readily to hand methods of forming. It was used considerably years ago for making dishes and its use

[1]The pewter of old is an alloy of tin, lead, and antimony. Many new alloys are now on the market and these vary in percentage composition as well as metal content. Britannia metal is a pewter alloy of tin, antimony, and copper. It is one of the high-grade alloys.

is being revived today by the craftsman. Pewter is very soft, does not corrode readily, and takes a high polish. Pewter, in sheets of various thicknesses, is available for construction work.

Pewter is used to make dishes, plates, mugs, etc. Because it shapes so easily it is used to make shallow bowls or plates by hand raising. Figure 254 shows pewter articles made by hand. See Unit 15 for instruction on raising.

A special flux for soldering pewter is 10 drops of hydrochloric acid in 1 ounce of glycerin. Bismuth soft solder is recommended, but regular half-and-half solder will do.

Reference:

Mersereau, Samuel Foster, *Materials of Industry* (New York: McGraw-Hill Book Company).

STUDY QUESTIONS:

1. State some of the properties of the metals.
2. Name several useful alloys.
3. What is said to be the most important metal?
4. What form of iron is mostly used?
5. What is the difference between mild steel and tool steel?
6. Describe copper and some of its uses.
7. State some properties of lead; some uses.
8. State some uses of aluminum.
9. What is "tin plate"?
10. State some uses of zinc.
11. What are the properties of pewter and its uses?

Unit 33

THE MANUFACTURE OF STEEL

Iron Deposits. Ages ago, torrents of water rushing through underground passages washed out the various kinds of soil, and chemically compounded the rusty iron deposits, accumulating them in great beds and pockets in the earth. Some of these are near the surface of the earth while others are many feet under the ground. These beds or pockets are called "deposits" and they contain the iron ore. When the ground is

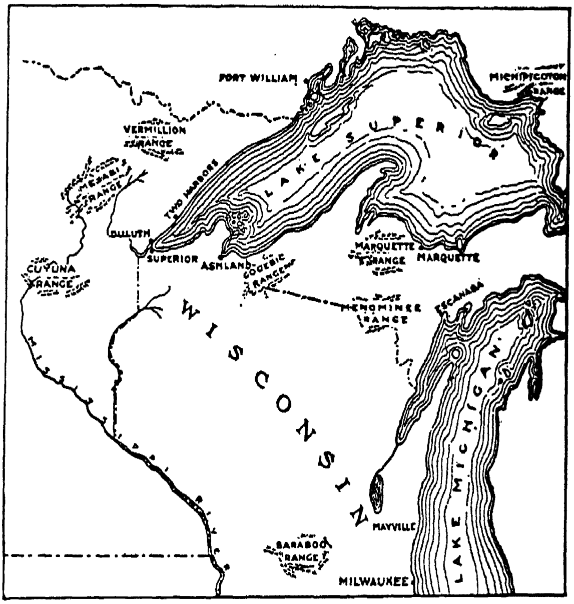

Fig. 257. Map showing the location of important iron mines in the Lake Superior region

opened for the purpose of extracting the ore, the excavation is known as a "mine" and the process as "mining."

Iron Ores. The material obtained from the mines is known as "iron ore." Iron ore is "iron rust mixed with dirt." It is the quantity and kind of dirt that really determine the value of the ore. This dirt contains such substances as phosphorus, silicon, sulphur, manganese, aluminum, lime, and magnesia. Phosphorus is the most undesirable dirt content. Ores

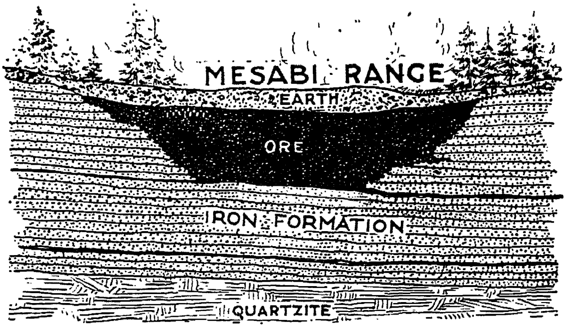

Fig. 258. Section of the Mesabi range in Minnesota showing iron-ore deposits near the earth's surface

with very little or no phosphorus are called "Bessemer" ores, and they are the most valuable. Those with considerable phosphorus are called "non-Bessemer" ores. Bessemer was the name of the man who invented the process of converting iron into steel; therefore such steel is called "Bessemer steel."

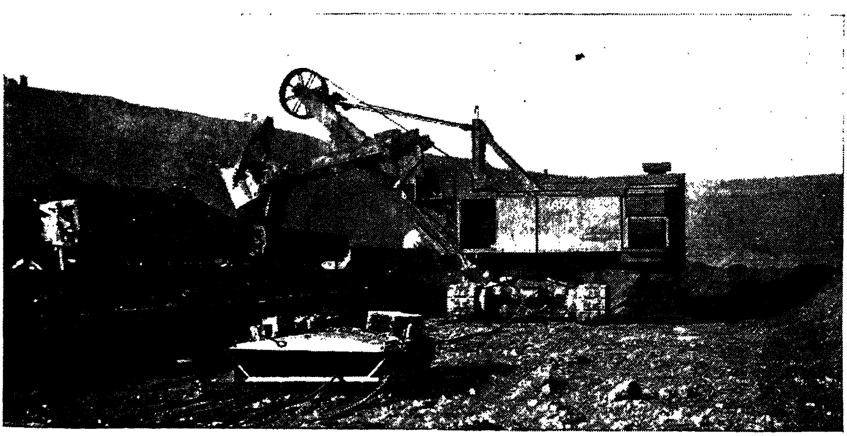

Fig. 259. An open mine in operation. This steam shovel places 600 tons of ore per hour into waiting railway cars

Iron Mines of the United States. The greatest iron-ore deposits in the world are in the Lake Superior region of the United States (see Fig. 257). The mines in this section supply nearly three fourths of the ore used in the United States and about one half of that used in the world. Here the iron ore in many mines is on top of the ground (see Fig. 258). This is a great advantage in obtaining the ore. In many cases it is only necessary to scoop up the ore with large steam shovels and dump it into waiting railroad cars. This makes the cheapest form of mining.

Other iron-ore deposits of importance are in Alabama, Colorado, and New York, but by far the greatest amount comes from the Superior region.

Railways Transport Iron Ore. As shown in Figure 259, waiting railroad cars are filled directly with a steam shovel. A steam shovel takes 5 tons to a scoop, 2 scoops a minute, or 600 tons an hour. These railroad cars, carrying 50 tons of ore each, are then run in long trains from the

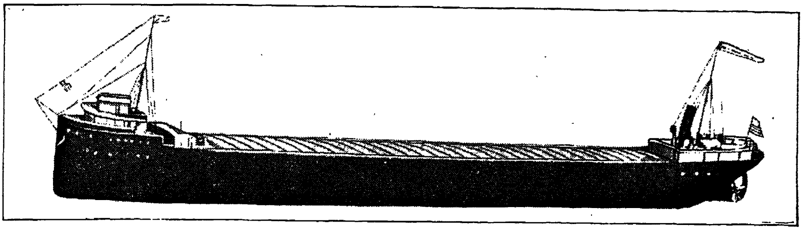

Fig. 260. An ore vessel. They are made as big as the Soo Canal locks will permit

mine to the shore of Lake Superior. Here the train mounts a high trestle over the shipping wharves, and the ore is dumped into bins holding 5 to 8 carloads each. The bins in turn are dumped into large ore ships (see Fig. 260). Only 2½ hours' time is required to load one of these huge ore vessels. Upward to 50 million tons of ore are brought down yearly from the Lake Superior mines.

Markets for the Iron Ore. Leaving Duluth or Two Harbors, the ore boats, loaded with about 10,000 tons each, steam for the cities of Chicago, Gary, Cleveland, and other points of destination on the Great Lakes. Every boat must pass through the Soo Canal, the outlet of Lake Superior. Figures show that more tonnage goes through this canal in eight months than passes through either the Suez or the Panama Canal in a year. At Conneaut, Ohio, and other Lake Erie ports the ore is again reloaded to railway cars and transported to Pittsburgh by rail. Here and in other cities great blast furnaces have been built in which the iron is obtained from the ore. The process of removing the iron from the ore is called smelting. You might ask, why move the heavy iron ore so far for smelting? The main reason is the use of coke in the smelting process. Coke is manufactured in the Pittsburgh district and it is more economical to move the ore than the coke.

Blast Furnaces. Iron ore is smelted in a blast furnace (see Fig. 261). A blast furnace is a large cylinderlike stove that reduces iron ore to pig iron. A standard blast furnace is 90 feet high and about 25 feet in diameter. This big furnace will produce from 500 to 700 tons of iron every day.

A blast furnace is very much like an old-fashioned, base-burner coal

stove. Fuel is fed in at the top and air at the bottom. The hot part of the fire is in the fire pot near the base. As the fuel burns out below, the charge above feeds down just like the coal in the base-burner magazine. While the load in a base burner is only several buckets of coal, the blast furnace's load may be 1,300 tons.

Charge of the Blast Furnace. The charge in a blast furnace consists

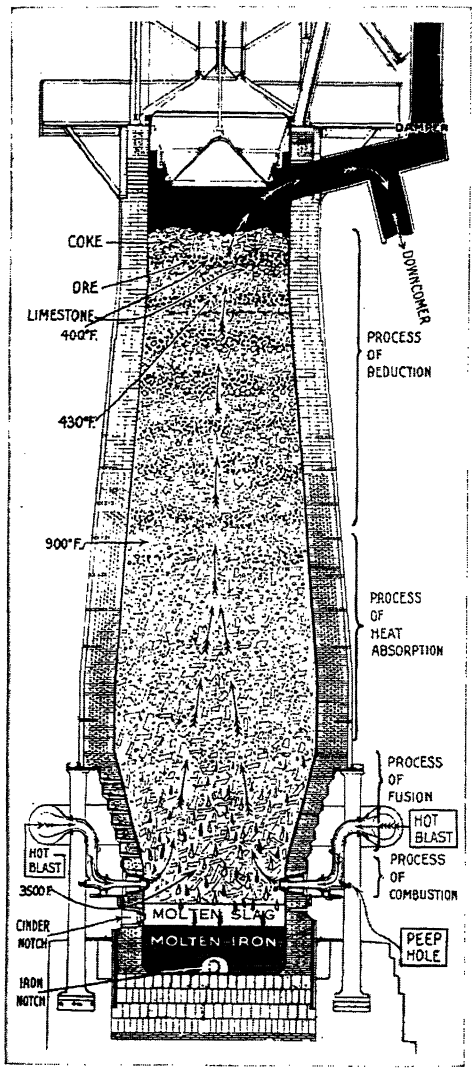

Fig. 261. Section of a blast furnace showing charge and operation

of alternate layers of iron ore, coke, and limestone. The ore furnishes the iron, the coke the intense heat, and the limestone draws out most of the dirt except phosphorus. Besides producing heat, the coke (which is 88 per cent carbon) adds carbon to the iron. The hot iron absorbs from about 3½ to 4 per cent of carbon. The limestone unites with the impurities to form a slag, which is a light, frothy substance that floats on the top of the molten mass of iron like cream on the surface of milk. This allows the impurities to be separated from the iron and the slag is drawn off frequently at an opening called the "cinder notch."

Gases from the Blast Furnace. As the blast furnace burns, it gives off a poisonous, combustible gas called "carbon monoxide." This is the same dangerous gas that is emitted by a running automobile engine. It is so poisonous that .7 per cent breathed with air will produce unconsciousness and 1 per cent is very dangerous to life. This gas, which burns readily, is used to run steam boilers and gas engines, and to preheat the air blast that is forced up through the bottom of the furnace. This last use is the most important.

Pig Iron. The blast furnace produces pig iron. This is iron with from 3½ to 4 per cent carbon plus other impurities. When the heat of the blast furnace is intense enough, the molten pig iron sinks to the bottom of the furnace. Here it is drawn off from the iron notch about every 4 hours. Each draw yields many tons of pig iron and takes about 30 minutes.

Bessemer Process of Making Steel. The molten pig iron from the blast furnace may be poured into a pear-shaped vessel called the Bessemer "converter" (see Fig. 262). This vessel is made of steel and is lined with thick firebrick. It is about 12 feet in diameter, 20 feet high, and mounted on pivots called "trunnions," so it can be tipped to receive molten iron and to discharge molten steel at its mouth. When a charge of molten pig iron is added, a current of air is forced up through the hot mass. The molten pig iron covers the bottom of the converter to a height of 18 inches. The air has a pressure of about 20 pounds per square inch, and causes the hot metal to boil and burn vigorously. This boiling removes the impurities (carbon, silicon, etc.) in about 10 minutes. The operator then tilts the converter and adds the necessary amount of carbon and other elements to make the kind of steel desired. The molten material is now finished steel and is poured out by tipping the converter. It is poured into large ladles and cast into ingots of suitable size for handling. By this method it takes only from 10 to 15 minutes to change 15 tons of pig iron to steel.

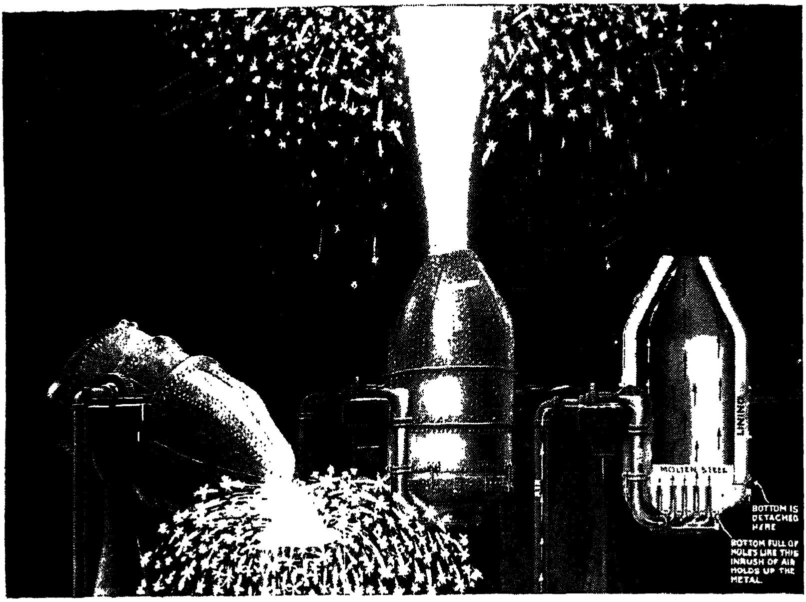

Fig. 262. Three views of a Bessemer converter: left, tipped; center, in action; right, cross section

Open-Hearth Process for Making Steel. Iron ores suitable to be used in the Bessemer converter have become more or less scarce, so those high in phosphorus content must now be used. These ores, because of the phosphorus, demand a different process, known as the "open hearth," for being made into steel. The open hearth is a large, shallow saucer or tray lined and inclosed with firebrick (see Fig. 263). The hearth or working bed is about 40 feet long and 16 feet wide. The charge consists of pig iron (often added from the blast furnaces) and scrap iron. This is the scrap iron generally found in the hands of junk dealers. Hot gases are forced into the furnace and burned above and around the charge until it melts and forms a molten mass. As the heating continues, the impurities burn off leaving almost pure iron. To make this iron into steel, weighed quantities of carbon and manganese are added just as in the Bessemer process. It takes upward to 12 hours, depending upon the quantity of the charge, to make steel by this method. The advantage of the open-hearth process is the removal of the objectionable phosphorus. It also makes use of the many tons of scrap iron that are formed and collected daily in this country. Formerly only poor grades of steel were made in the open-hearth furnace, but modern methods have improved the product

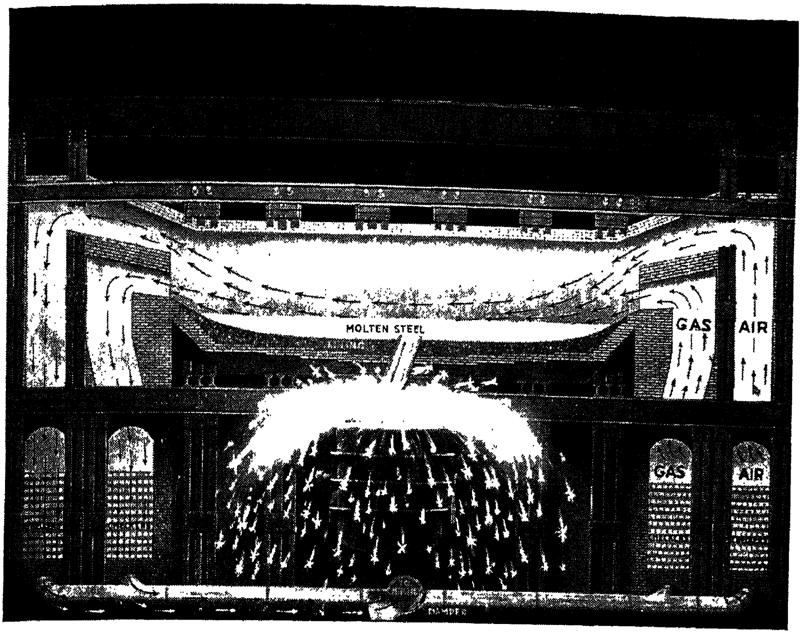

Fig. 263. The cross section of an open-hearth furnace

greatly. Much of the steel used in automobile construction is now made in the open-hearth furnace.

References:

The Manufacture of Steel (Chicago: American Steel & Wire Co.).
Spring, L. W., *Non-Technical Chats on Iron and Steel* (N.Y.: F. A. Stokes Co.)
A B C of Iron and Steel (Cleveland: Penton Pub. Co.).
Camp, J. M., and Francis, C. B., *Making, Shaping and Treating of Steel* (Pittsburgh: Carnegie Steel Co.).

STUDY QUESTIONS:

1. What is iron ore?
2. What are some of the impurities often found in iron ore?
3. What is a Bessemer ore? a non-Bessemer ore?
4. Where are the greatest iron-ore deposits?
5. How is the iron ore transported to Chicago, Cleveland, and Pittsburgh?
6. What is a blast furnace like?
7. State the use of each ingredient of a blast furnace.
8. Tell something about carbon-monoxide gas.
9. What is pig iron?
10. Explain how the Bessemer converter makes steel from pig iron.
11. Explain the open-hearth method of making steel.

INDEX